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A Continuing Bibliography with Indexes

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 230)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in August 1988 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 563 reports, journal articles and other documents originally announced in August 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER →	**N88-10026*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.	←	CORPORATE SOURCE
TITLE →	**HIMAT FLIGHT PROGRAM: TEST RESULTS AND PROGRAM ASSESSMENT OVERVIEW**		
AUTHORS →	DWAIN A. DEETS, V. MICHAEL DEANGELIS, and DAVID P. LUX		
PUBLICATION DATE →	Jun. 1986 30 p		
REPORT NUMBERS →	(NASA-TM-86725; H-1283; NAS 1.15:86725) Avail: NTIS HC	←	AVAILABILITY SOURCE
PRICE CODE →	A03/MF A01 CSCL 01C	←	COSATI CODE

The Highly Manueverable Aircraft Technology (HiMAT) program consisted of design, fabrication of two subscale remotely piloted research vehicles (RPRVs), and flight test. This technical memorandum describes the vehicles and test approach. An overview of the flight test results and comparisons with the design predictions are presented. These comparisons are made on a single-discipline basis, so that aerodynamics, structures, flight controls, and propulsion controls are examined one by one. The interactions between the disciplines are then examined, with the conclusions that the integration of the various technologies contributed to total vehicle performance gains. An assessment is made of the subscale RPRV approach from the standpoint of research data quality and quantity, unmanned effects as compared with manned vehicles, complexity, and cost. It is concluded that the RPRV technique, as adopted in this program, resulted in a more complex and costly vehicle than expected but is reasonable when compared with alternate ways of obtaining comparable results.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

ON MICROFICHE

ACCESSION NUMBER →	**A88-10095#**		
TITLE →	**SYNTHESES OF REDUCED-ORDER CONTROLLERS FOR ACTIVE FLUTTER SUPPRESSION**		
AUTHORS →	ATSUSHI FUJIMORI and HIROBUMI OHTA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 402, 1987, p. 353-362. In Japanese, with abstract in English. refs	←	JOURNAL TITLE

Reduced-order controllers for active flutter suppression of a two-dimensional airfoil are studied using two design approaches. One is based on the generalized Hessenberg representation (GHR) in the time domain, and the other, called the Nyquist frequency approximation (NFA), is a method in the frequency domain. In the NFA method, the reduced-order controllers are designed so that the stability margin of the Nyquist plot may be increased over a specific frequency range. To illustrate and to make a comparison between the two methods, numerical simulations are carried out using a thirteenth-order controlled plant. It is to be noted that the GHR method can yield quasi-optimal controllers in the sense of minimizing quadratic performance indices. The designed controllers, however, do not have enough stability margin, and the order reduction resulting from full state controllers may not be satisfactory. On the other hand, reduced-order controllers in the NFA method can be designed with increased stability margin at the expense of the performance index. For all simulation cases, the NFA method yields second-order controllers with a better stability margin than those by the GHR method. Thus, the NFA method provides an effective method for synthesizing robust reduced-order controllers.

Author

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A Continuing Bibliography (Suppl. 230)

SEPTEMBER 1988

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AERONAUTICS (GENERAL)

A88-37176
INTERNATIONAL POWERED LIFT CONFERENCE AND EXPOSITION, SANTA CLARA, CA, DEC. 7-10, 1987, PROCEEDINGS
Conference and Exposition sponsored by SAE, DOT, DOD, and NASA. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE P-203), 1988, 815 p. For individual items see A88-37177 to A88-37238.
(SAE P-203)

The present conference on VTOL, STOVL and V/STOL fixed-wing aircraft powered lift discusses hot gas recirculation in V/STOL, flight testing of a single-engine powered lift aircraft, RAF experience with VTOL, near-term improvements of the AV-8B Harrier II, recent advancements in thrust augmentation, lift ejectors for STOVL combat aircraft, the correlation of entrainment and lift enhancement for a two-dimensional propulsive wing, the thrust efficiency of powered lift systems, and flight propulsion control integration for V/STOL aircraft. Also discussed are VSTOL design implications for tactical transports, the numerical investigation of a jet in ground effect with a cross flow, the NASA supersonic STOVL propulsion technology program, the aeroacoustics of advanced STOVL aircraft plumes, powered lift transport aircraft certification criteria status, the application of vectored thrust V/STOL experience in supersonic designs, wave drag and high speed performance of supersonic STOVL fighter configurations, and the impact of bypass ratio on thrust-to-weight for V/STOL.
O.C.

A88-37205
ADVANCED TACTICAL TRANSPORT NEEDS AND DESIGN IMPLICATIONS
ROY C. LECROY and THOMAS B. BARNES (Lockheed-Georgia Co., Marietta) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 371-379. refs
(SAE PAPER 872337)

A comprehensive data base has been developed for the critical mission requirements of a next-generation technology Advanced Tactical Transport, and six alternative baseline design concepts (ASTOL, STOL, and VSTOL, with and without low-observability technology) are considered in view of relative mission effectiveness, cost, supportability, survivability, technology, and system programmatics. The data base used is sufficiently wide-ranging and detailed to support the inclusion of affordability and operational policy considerations in the requirements-definition phase of a development program.
O.C.

A88-37206
VSTOL DESIGN IMPLICATIONS FOR TACTICAL TRANSPORTS
JAMES W. WOLLASTON and DERRELL L. BROWN (Douglas Aircraft Co., Long Beach, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 381-392.
(SAE PAPER 872338)

The advanced Transport Technology Mission Analysis (ATTMA) study, a broad-based investigation of future tactical airlift system concepts, identified the need for an Advanced Tactical Transport (ATT) to support friendly forces on the extended airland battlefield, including deep operations. This paper, which is based on the study, discusses the three major issues for tactical airlift in this environment: the size of the ATT required to support deep operations, the survivability of a penetrating airlifter and its related design requirements, and the suitability of STOL and VSTOL designs for delivery near the desired destination, with limited ground exposure. Finally, the design implications of VSTOL are addressed, and a VSTOL ATT is shown to be cost-competitive with the C-130. However, a STOL ATT has the lowest cost of all alternatives examined.
Author

A88-37238* Royal Aircraft Establishment, Farnborough (England).
OVERVIEW OF THE US/UK ASTOVL PROGRAM
FRANK W. ARMSTRONG (Royal Aircraft Establishment, Farnborough, England) and JACK LEVINE (NASA, Washington, DC) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 797-805.
(SAE PAPER 872365)

An account is given of progress to date in a US/UK advanced, supersonic flight-capable, powered-lift aircraft development collaborative effort formalized in January, 1986 by a memorandum of understanding (MOU). MOU-related work has investigated such ASTOVL propulsion configuration concepts as the remote augmented lift system, using a two-mode powerplant; augmenting ejectors, which generate a more benign ground environment; plenum chamber burning vectored thrust, which elaborates the geometry of the Harrier Pegasus powerplant; and tandem fans, which are also closely related to the Harrier concept but incorporate a truly variable-cycle engine.
O.C.

A88-37297#
NEW STRUCTURAL TECHNOLOGIES FOR THE DORNIER 328 FUSELAGE
EBERHARD JOHST and REINER TESKE Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 55-58.

The Do 328 regional airliner will employ a variety of novel materials and structures techniques in its 30-passenger pressurized fuselage in order to achieve the requisite lightness, cost-efficiency, and acoustical optimization. Attention is presently given to the results obtained to date with test articles in which the Al-Li material and structural design techniques to be used in the Do 328 have been subjected to severe fatigue and acoustical tests, with a view to pressurized fuselage damage tolerance and cabin noise attenuation.
O.C.

A88-38710#
SKUNK WORKS PROTOTYPING
HAROLD C. FARLEY and RICHARD ABRAMS (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Flight Test

Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 72-84.
(AIAA PAPER 88-2094)

This paper discusses the Skunk Works' management approach to prototype development programs. A historical perspective of different types of prototype programs is presented along with descriptions of some of the more notable Skunk Works' prototypes. The paper then highlights the Company's preferred system of management along with important factors to be considered in the planning and conduct of a prototype program. Author

A88-38723#
AIR FORCE ONE REPLACEMENT PROGRAM - AN APPLICATION OF ACQUISITION STREAMLINING AND FEDERAL AVIATION ADMINISTRATION CERTIFICATION
ROBERY I. MARX, RAYMOND E. JOHNS (USAF, Wright-Patterson AFB, OH), and JOHN T. HIGGS (Boeing Military Airplane Co., Seattle, WA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 184-205. refs
(AIAA PAPER 88-2123)

Acquisitions-streamlining imperatives recently instituted at the U.S. DOD have led to a growing reliance on the FAA certification of military-derivative aircraft. Attention is presently given to the Air Force One Replacement Program, also known as the VC-25A, in which commercial acquisition and testing practices will be applied to two Boeing 747-200 aircraft. The impact of concurrent development, test, and production on the more accustomed methods of DOD acquisition are discussed, and further recommendations for acquisition streamlining are formulated. O.C.

A88-38752#
TESTING NEW AIRCRAFT - IS THERE AN R&M CHALLENGE?
PETER BITTER IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 453-462.
(AIAA PAPER 88-2182)

Due to the growing complexity of new aircraft, the fulfillment of reliability and maintainability (R&M) requirements during flight testing is becoming more difficult to achieve. Attention is presently given to the role of supportability criteria in flight tests, R&M data-collection methods, proof-of-compliance testing techniques, and the consolidation of design assumptions for environmental stress. O.C.

A88-38753#
MAINTAINABILITY - A DESIGN PARAMETER
JAMES E. HOFF (BDM Corp., Albuquerque, NM) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 463-468.
(AIAA PAPER 88-2184)

This paper discusses maintainability as a design parameter. The discussion is slanted to provide the design engineer with the user prespective of maintainability. It presents the various maintainability factors that are evaluated by the users operational test and evaluation agency. Author

A88-38754#
RELIABILITY AND MAINTAINABILITY EVALUATION DURING FLIGHT TEST
JAN M. HOWELL (USAF, Edwards AFB, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 469-473.
(AIAA PAPER 88-2185)

Extensive reliability and maintainability (R&M) evaluations, quantitative and qualitative, are accomplished during initial testing to ensure that the highest quality weapons system is delivered to the user within cost and schedule constraints. Because of the ever increasing cost-of-ownership of modern weapons system, the emphasis on these evaluations is increasing proportionately. This paper presents an overview of these evaluations. The objectives, methodology used and information available from such evaluations are discussed. The statistical analysis and methods normally associated with the R&M engineering discipline is deemphasized. Author

A88-39325
OSPREY'S VSLED - REWRITING THE MAINTENANCE MANUAL
EDWARD W. BASSETT Rotor and Wing International (ISSN 0191-6408), vol. 22, June 1988, p. 32, 49.

The V-22 Osprey tilt-rotor VTOL aircraft's vibration, structural life, and engine diagnostics (VSLED) system, which is intended to increase in-flight safety and reduce the number of maintenance hours by 50 percent by comparison with helicopters of equivalent class, consists of a 16-bit/word airborne computer unit and a sensor network. The VSLED will analyze data and generate a status report advising V-22 maintenance crews as to the need to repair, overhaul, or replace airframe or engine components. The sensors furnish data on rotor vibration, wing root and empennage strain, and engine vibration. VSLED calculates four life-usage indices through its engine-monitoring features. O.C.

A88-39416#
CFRP LANDING FLAPS FOR THE AIRBUS A320
WOLFGANG STAEUDLIN and ERNST KLANN Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 31-33.

The A320 airliner's wing landing flap consists of a CFRP torque box with metallic attachment and drive fittings, a CFRP sandwich shell leading edge structure, and a two-part metallic, lightning-protection trailing edge. The torque-box's stringer-reinforced shells are produced as integral parts in one curing process. Flap sectional and bearing loads, together with the very complex bearing and drive structures, were calculated by FEM; CADAM was used throughout, as were NC procedures for fittings. Tests have established that a 4-lb birdstrike at 84 m/sec would not result in flap loss. O.C.

A88-40386
IR GROUP ACTIVITIES AT THE ISRAEL AIRCRAFT INDUSTRIES
S. JACOBSON, S. WEISROSE, M. LINDNER, Z. LISSAK, Y. YOAV (Israel Aircraft Industries, Ltd., Lod, Israel) et al. IN: Infrared technology XIII; Proceedings of the Meeting, San Diego, CA, Aug. 18-20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 139-149.

Fields of active IR technology development at Israel Aircraft Industries are evaluated with a view to expansion of the state-of-the-art in IR signature prediction and measurement through a program of ground static and dynamic flight studies. Attention is given to software capabilities for the calculation of different targets' IR signatures. The accuracy of some of these codes has been demonstrated by comparison with experimental data. O.C.

A88-40522
AEROSPACE EQUIPMENT - EVOLUTION AND FUTURE PROBLEMS [LES EQUIPEMENTS AEROSPATIAUX - EVOLUTION ET PROBLEMES D'AVENIR]
MICHEL HUCHER Navigation (Paris) (ISSN 0028-1530), vol. 36, April 1988, p. 253-267. In French.

The status of the French aircraft equipment industry is reviewed, and the navigation segment is analyzed, with emphasis on civil aviation applications. Data show the relative importance of the French industry in helicopter and business aircraft manufacturing with respect to the world market. Radionavigation equipment is considered, and the technology involved in the Navstar/GPS system is described. Inertial guidance systems for autonomous aircraft navigation are also discussed, with particular attention given to the A320 Air Data and Inertial Reference System. R.R.

A88-40532#
OPTICAL TECHNOLOGY APPLICATION IN AIRCRAFT

KIYOMICHI MITSUHASHI, RYOZO SEO, and MASAHIKO YOKOTA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 408, 1988, p. 18-25. In Japanese.

A88-40552* National Aeronautics and Space Administration, Washington, D.C.

ROTORCRAFT RESEARCH AT NASA

JOHN S. BURKS (NASA, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 12-17.

An overview of NASA research in rotorcraft technology is presented. Ten percent of the NASA aeronautics program is made up of rotorcraft research. The aeronautics program conducts research in five areas: aerodynamics, propulsion, materials and structures, information sciences and human factors, and flight systems. The key objectives of NASA research are major reduction in external noise and aircraft vibration, reduction of pilot workload for night, adverse weather and NOE flying, increasing power and reducing fuel consumption in small engines, and identifying and exploiting vehicle characteristics and concepts for triple current speed and improved maneuverability and agility. NASA and Army resources are combined to pursue research at three major centers. The Ames research center conducts research in the physics of transition and turbulent flows, using a new improved wind tunnel and the NAS system. At the Langley Research Center, work is done in noise and vibration reduction, finding lighter and more durable composite structures, and aeroelasticity for tilt motors and X-wing configurations. At the NASA Lewis Research Center, researchers are working on improving helicopter propulsion systems. R.B.

A88-40553* National Aeronautics and Space Administration, Washington, D.C.

THE NASA/AHS ROTORCRAFT NOISE REDUCTION PROGRAM

OTIS S. CHILDRESS, JR. (NASA, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 18-22.

Research of the NASA/AHS noise reduction program is discussed, stressing work in four areas: noise prediction, testing and data base, noise reduction, and criteria development. A program called ROTONET has been developed, using a code structure divided into four main parts; main- and tail-rotor blade geometry, rotor performance, noise calculations, and noise propagation. Wind tunnel tests on individual rotors, and flight tests on a helicopter built specifically to generate a broadband main rotor noise data base have been conducted. In the field of noise reduction, researchers have performed analytical evaluations of low noise rotor concepts, and small-scale wind tunnel evaluations of noise reduction concepts. Under the supervision of the FAA, the program in conducting tests to develop criteria for helicopters and heliports. R.B.

A88-40555

RISING TO THE CHALLENGE - RESEARCH AT AATD

JOHN E. KEMPSTER (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 32-36.

Six helicopter related R&D programs of the U.S. Army's Aviation Applied Technology Directorate (AATD) are discussed. The Advanced Composite Airframe Program (ACAP) studies advanced composite materials and design concepts to reduce acquisition cost and airframe structural weight and to improve production and structural performance. ACAP is also investigating the use of composite airframe structures to improve crashworthiness, lightning strike protection and internal acoustic noise levels. The Advanced Digital/Optical Control System (ADOCS) uses digital control law processing and fiber-optic data transmission to improve helicopter combat capability. The Turbine Advanced Gas Generator-Medium/Engine 21 (TAGG-M/Engine 21) program studies engine design to provide advanced propulsion technology for military helicopters. The Advanced Technology Demonstrator Engine (ATDE) program evaluates levels of engine technology for transition into a low-risk engineering development program. The Multi-Sensor Fusion Demonstration Program (MSFD) is researching the amount and type of information that can be displayed to the complex combat vehicle/aircraft operator. The Enhanced Diagnostic System program is used to implement extensive diagnostic capabilities at the component level and provide expert system test equipment. R.B.

A88-40556

THE ROTORCRAFT CENTER OF EXCELLENCE AT THE UNIVERSITY OF MARYLAND

J. GORDON LEISHMAN and ALFRED GESSOW (Maryland, University, College Park) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 46-50.

Study at the Center for Rotorcraft Education and Research (CRER) at the University of Maryland is discussed. Research at CRER focuses on rotating wing technology, including dynamics, aerodynamics, aeroelasticity, structures and composite materials, flight mechanics and the interactions of these disciplines. Specific topics of research include aeroelastic stability, the dynamics of composite rotor blades, the application of higher harmonic control (HHC) to reduce inherent vibration, the effects of interactions between the rotor and the fuselage, flight mechanics, and composite structures. Rotorcraft research facilities at CRER include a rotor test rig for testing hub and blade configurations in hover and forward flight, a structural dynamics test facility and a composite materials laboratory. R.B.

A88-40557

RESEARCH AT RENSSELAER POLYTECHNIC INSTITUTE'S CENTER OF EXCELLENCE IN ROTORCRAFT TECHNOLOGY

ROBERT G. LOEWY (Rensselaer Polytechnic Institute, Troy, NY) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 53-59. refs

A discussion of research at the Rensselaer Polytechnic Institute's Rotorcraft Technology Center (RPI-RTC) is given, stressing study in four areas: materials and structures for rotorcraft, structural dynamics of components unique to rotorcraft, unsteady aerodynamics of rotors, and aeroelasticity of rotors and rotor/fixed airframe combinations. Research in materials and structures emphasizes composite structures to prevent warping and fatigue. The center is researching rotorcraft drive shaft system design and fuselage structural dynamics. In the field of rotor unsteady aerodynamics, the center studies compressibility by generating a two-dimensional vortex and observing its interaction with a two-dimensional lifting. Two studies in rotor aeroelasticity are being conducted, one to establish methodology which could account for the nonlinearities associated with large deflections and moderate rotations, and another examining the effect of rotor blade nonlinear dynamics on forced response. R.B.

A88-40558

1987 TECHNICAL COMMITTEE HIGHLIGHTS - THE YEAR IN REVIEW

RAJARAMA K. SHENOY, KENNETH R. READER, EVAN A. FRADENBURGH, CARL J. BENNING, GENE SADLER et al. Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 60-70, 72-79.

Reports from the AHS Technical Committees for 1987 are given, discussing advances in various fields of helicopter research, including dynamics, propulsion, manufacturing and product assurance, military operations, and product support. In the field of acoustics, external and internal noise research continued, and new developments were made in noise prediction methodology. In aerodynamic studies, progress was made in the areas of CFD and experimental data base development, with studies on rotor wakes and airflow, and BVI. In the field of aircraft design, two new helicopters, the Boeing 360 Tandem Rotor and the Westland-Agusta EH 101, were introduced and tilt rotor research continued. LHX activities dominated the field of avionics and systems. In structures and materials research, work was done in composite structures design, fabrication, and testing. Test and evaluation activities have focused on modifications to or variants of existing military and commercial aircraft, research into emerging technology, and technology demonstrations for future VTOL applications. R.B.

A88-40559
AIRCRAFT WITHOUT AIRPORTS - CHANGING THE WAY MEN FLY
HANS MARK (Texas, University, Austin) and ROBERT R. LYNN (Bell Helicopter Textron, Fort Worth, TX) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 80-83, 86, 87.

Tilt rotor vehicles are discussed, giving the history, present state, and prospects for future development of rotor tilt technology. An overview of tilt rotor aircraft designs from 1938 up to the present is given, culminating with the introduction of the V-22 Osprey, currently being developed for the Marine assault mission. The Osprey will have over 300 knot speed capability and an altitude of up to 30,000 ft, combined with helicopter-type hover ability. The Osprey will be largely constructed from high strength graphite. A commercial version of the Osprey is expected by 1995. New developments in tilt rotor designs will provide increased speed, lower weight and increased payload, making the use of tilt rotor craft for commercial passenger flying more feasible. R.B.

A88-40560
RESEARCH AND DEVELOPMENT AT BOEING HELICOPTERS
BRUCE B. BLAKE (Boeing Helicopters, Philadelphia, PA) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 90-95.

The Boeing Helicopters R&D program, involving the Army's CH-47D/MH-47E Chinook medium lift helicopter, the V-22 Osprey multi-service TiltRotor aircraft, and the Army's LHX armed reconnaissance aircraft is discussed, stressing developments in aeromechanics and vehicle design, new materials applications, and flight controls and avionics. The Osprey program was the first rotorcraft program to make significant use of CFD methods. CFD codes have also been applied to rotor acoustic analysis and prediction. Composites have been used to reduce craft weights and improve aerodynamic efficiency, safety, and survivability. Research is being conducted to improve inspection methods and to reduce the cost of composites. Digital electronics systems have reduced cost per function and increased craft capability as a weapon system. The Advanced Digital/Optical Control System (ADOCS) is being used. Other research has focused on the Boeing Model 360 Advanced Technology Demonstrator aircraft, which has an integrated flight management system, incorporating digital avionics and cathode ray tube displays. R.B.

A88-40561
ROTORCRAFT TECHNOLOGY DEVELOPMENT AT SIKORSKY AIRCRAFT
PETER ARCIDIACONO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 96-101.

Work done at Sikorsky Aircraft in advanced rotors, advanced airframes, vibration and noise, vehicle flight management, cost of ownership and advanced and alternative rotorcraft is discussed in detail. Studies of rotors include making optimum use of composites, metals and elastomerics, developing bearingless main rotors utilizing flexbeams, and improving airfoil and rotor performance. Airframe research is making use of metals and composites, especially aluminum-lithium, to decrease craft weight. CFD and computational structural dynamics are being used to reduce vibration and internal noise. In the field of vehicle flight management, analyses, software techniques, and simulation hardware are being developed to study and integrate the elements of man-machine interface. Ways of reducing cost are sought through designing new hardware with MANPRINT requirements in mind and employing emerging new technology involved with structural and mechanical systems monitoring. Studies in alternative rotorcraft configurations have focused on the X-wing vehicle. R.B.

A88-40562
CURRENT ROTORCRAFT TECHNOLOGY ADVANCEMENT AT MBB
HELMUT B. HUBER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 106-112.

A review of rotorcraft R&D at MBB is given. In the area of aerodynamics, research focuses on developing and testing advanced rotor blade airfoils. Research on new rotor systems includes the development of a 5-blade hingeless rotor system and work on bearingless main rotors and tail rotors. Anti-vibration research stresses the study of vibration control by rotor isolation and active control techniques. Studies of composite airframe structures are being conducted, using the BK 117 as a technology demonstrator and avionics systems are tested both in flight and with the CGI-Simulator. Technology used in research includes CFD-codes, mathematical helicopter models, and two new simulators, and special configurations are being developed for a European tilt rotor aircraft and a single-pilot fighter aircraft compounded with a ducted fan propulsor. R.B.

N88-22003# Transportation Systems Center, Cambridge, Mass.
GENERAL AVIATION ACTIVITY AND AVIONICS SURVEY: 1986 DATA Annual Summary Report
Dec. 1987 290 p
(AD-A189986; DOT-TSC-FAA-87-5; FAA-MS-87-5) Avail: NTIS HC A13/MF A01 CSCL 01C

This report presents the results and description of the 1986 General Aviation Activity and Avionics Survey. The survey was conducted during 1987 by the FAA to obtain information on the activity and avionics of the United States registered general aviation aircraft fleet, the dominant component of civil aviation in the U.S. The survey was based on a statistically selected sample of about 10.5 percent of the general aviation fleet. A response rate of 54.6 percent was obtained. Survey results are based upon responses but are expanded upward to represent the total population. Survey results revealed that during 1986 an estimated 34.4 million hours of flying time were logged and 95.1 million operations were performed by the 220,044 active general aviation aircraft in the U.S. fleet. The mean annual flight time per aircraft was 148.9 hours. The active aircraft represented about 81.9 percent of the registered general aviation fleet. The report contains breakdowns of these and other statistics by manufacturer/model group, aircraft type, state and region of based aircraft, and primary use. Also included are fuel consumption, lifetime airframe hours, avionics, engine hours, and miles flown estimates, tables for detailed analysis of the avionics capabilities of the general aviation fleet, estimates of the number of landings, IFR hours flown, and the cost and grade of fuel consumed by a GA fleet. GRA

N88-22855 Deutsche Lufthansa Aktiengesellschaft, Cologne (West Germany).
ACTIVITIES REPORT OF LUFTHANSA Annual Report, 1987 [LUFTHANSA JAHRBUCH '87]
HANS-JOACHIM ALLGAIER, ed. 31 May 1987 309 p In GERMAN
(ISSN-0176-5086; ETN-88-91474) Avail: Fachinformationszentrum Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, Fed. Republic of Germany

The economic significance of Lufthansa; Lufthansa in the capital market; flight as a financial problem; pilot education; responsibility of the aircraft captain; aircraft safety; use of twin-engine long distance aircraft; customer information; operation of the Frankfurt air freight center; and Airbus Industries are discussed. The evolution of European air traffic policy; extraterrestrial application of air law, and the status of aircraft engineering are reviewed. ESA

N88-22856# Fokker B.V., Amsterdam (Netherlands).
ACTIVITIES REPORT IN AEROSPACE Annual Report, 1986 [JAARVERSLAG 1986]
1986 60 p In DUTCH Original contains color illustrations
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The development, production, and commercial activities related to the F-27 Friendship, Fokker 50, Fokker 100, Airbus 300, Airbus 310, Short 330, Short 360, and F-16 are summarized. Planned research activities in astronautics are mentioned. ESA

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A88-37112

THE USE OF OPTIMIZATION TECHNIQUE AND THROUGH FLOW ANALYSIS FOR THE DESIGN OF AXIAL FLOW COMPRESSOR STAGES

ARISTIDE MASSARDO and ANTONIO SATTA (Genova, Universita, Genoa, Italy) IN: Conference on Fluid Machinery, 8th, Budapest, Hungary, Sept. 1987, Proceedings. Volume 1. Budapest, Akademiai Kiado, 1987, p. 455-463. refs

In the present automated procedure, which has been developed for the aerodynamic design optimization of axial flow compressor stages' geometry, a numerical optimization technique is coupled with a code that conducts a through-flow analysis. Losses are evaluated on the basis of correlations derived from the available literature, and results characterized by good stability, high precision, and short calculation times are established. Attention is given to illustrative examples. O.C.

A88-37177

HOVER SUCKDOWN AND FOUNTAIN EFFECTS

RICHARD E. KUHN IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 1-17. refs

(SAE PAPER 872305)

The flow fields encounterd by jet- and fan-powered vertical/short takeoff and landing (V/STOL) aircraft when hovering in ground effect are reviewed, and their effects on the aerodynamic characteristics are discussed. The ground effects considered include the suckdown generated by the flow from a single nozzle, the fountain effects generated by multiple-nozzle configurations, and the additional suckdown associated with the fountain flow generated by multiple-nozzle configurations. Current understanding of the flow fields involved, and the capability and limitations of available methods for estimating the effects of ground proximity, are reviewed and the areas where additional work is needed are discussed. Author

A88-37178

HOT GAS RECIRCULATION IN V/STOL

C. M. MILFORD (British Aerospace, PLC, Military Aircraft Div., Kingston-upon-Thames, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 19-29. refs

(SAE PAPER 872306)

An account is given of hot gas recirculation (HGR) mechanisms in V/STOL aircraft, as well as of ways in which to assess and control it, since severe HGR can result in large thrust losses and compressor stall. Since full scale data on HGR is limited, it is necessary to rely heavily on model testing. Attention is accordingly given to scaling principles; it is shown that it is not possible to achieve similarity in all test parameters simultaneously. CFD is noted to show promise, but a full, time-dependent HGR computation remains beyond the capability of generally available computers. O.C.

A88-37179* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PROPULSION-INDUCED EFFECTS CAUSED BY OUT-OF-GROUND EFFECTS

RICHARD MARGASON (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 31-57. Previously announced in STAR as N88-14088. refs

(SAE PAPER 872307)

Propulsion induced effects encountered by moderate- to high-disk loading STOVL or VSTOL aircraft out-of-ground effect during hover and transition between hover and wing-borne flight are discussed. Descriptions of the fluid flow phenomena are presented along with an indication of the trends obtained from experimental investigations. In particular, three problem areas are reviewed: (1) the performance losses sustained by a VSTOL aircraft hovering out-of-ground effect, (2) the induced aerodynamic effects encountered as a VSTOL aircraft flies on the combination of powered and aerodynamic lifts between hover and cruise out-of-ground effect, and (3) the aerodynamic characteristics caused by deflected thrust during maneuvering flight over a wide range of both angle of attack and Mach number. Author

A88-37180

EFFECT OF GROUND PROXIMITY ON THE AERODYNAMIC CHARACTERISTICS OF THE STOL AIRCRAFT

VEARL R. STEWART IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 59-73. refs

(SAE PAPER 872308)

The aerodynamics of the STOL aircraft can experience significant changes in proximity to the ground. A review of the existing data base and methodologies has been made and the results of that review are presented in this paper. The existing data show that in ground proximity the STOL aircraft will generally experience a reduction in the lift component regardless of the lifting configuration. Those configurations with integrated power and lift systems will have an additional effect of ground induced aerodynamic changes. This paper will discuss the existing data base and the deficiencies of that data base. Author

A88-37181

THE GROUND ENVIRONMENT CREATED BY HIGH SPECIFIC THRUST VERTICAL LAND AIRCRAFT

P. G. KNOTT (British Aerospace, PLC, London, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 75-85. refs

(SAE PAPER 872309)

When high specific thrust engines vectored for vertical landing are in ground proximity, the high-pressure, high-temperature exhaust plumes create a hostile environment for the aircraft, ground crew, equipment, and landing platform. An account is presently given of the physical nature of the ground surface erosion, near-field/midfield noise, upwash impingement on aircraft, and ground sheet temperature problems that arise in these conditions, with a view to the formulation of suggestions toward their amelioration. O.C.

A88-37194

CORRELATION OF ENTRAINMENT AND LIFT ENHANCEMENT FOR A TWO-DIMENSIONAL PROPULSIVE WING

D. R. WILSON, C. S. JEON, B. R. WINBORN (Texas, University, Arlington), and C. PERNICE IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 235-242. refs

(SAE PAPER 872325)

Wind tunnel model flow entrainment and lift enhancement results for a modified NACA 0025 airfoil section with propulsive nozzle exhausting over the upper surface of the airfoil at the

70-percent chord position are presented and correlated for alpha values of -5, 0, 5, 10, and 15 deg; wind tunnel dynamic pressures were 0, 1, 5, and 10 lbf/sq ft. The lift coefficient and entrainment velocity increment were found to directly correlate with the propulsive velocity increment. Linear correlations based on momentum pressure parameters using a 'neutral point' concept were also found to provide an excellent correlation of lift enhancement and entrainment velocity. O.C.

A88-37195
EXPERIMENTAL INVESTIGATION OF A JET IMPINGING ON A GROUND PLANE IN THE PRESENCE OF A CROSS FLOW
J. M. CIMBALA, D. R. STINEBRING, A. L. TREASTER, M. L. BILLET (Pennsylvania State University, University Park), and M. M. WALTERS (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 243-251. Navy-supported research. refs
(SAE PAPER 872326)

An experimental investigation has been conducted in a wind tunnel to model the impingement of high velocity jet exhaust flow on the ground, as encountered by vertical or short takeoff and landing (VSTOL) aircraft. A constant jet velocity was maintained while varying the wind tunnel cross flow velocity, upstream boundary layer thickness, and height from the ground to the jet exit plane. The radial wall jet, when interacting with the cross flow, forms an oscillating horseshoe-shaped separation bubble, commonly referred to in the literature as a ground vortex. The streamwise distance of the separation point from the jet impingement point is documented here as a function of the flow parameters and geometry. Flow visualization of the flow field above the ground plane and two-component laser Doppler velocimeter measurements taken through the separation bubble indicate that the separation bubble is highly unsteady and non-symmetric. This unsteadiness may be related to shear layer vortices shed from the lip of the jet. Author

A88-37209* Florida Univ., Gainesville.
NUMERICAL SIMULATION OF A SUBSONIC JET IN A CROSSFLOW
KARLIN R. ROTH (Florida, University, Gainesville) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 425-431. refs
(Contract NCC2-403)
(SAE PAPER 872343)

The aerodynamic/propulsive interaction between a subsonic jet exhausting perpendicularly through a flat plate into a crossflow is investigated numerically using an approximately factored, partially flux-split, implicit solver for the three-dimensional, thin-layer Navier-Stokes equations. This algorithm is applied to flows with a range of jet-to-crossflow velocity ratios between 4 and 8. The computations model the jet trajectory, the contrarotating vortex pair and the wake region near the plate downstream of the jet orifice. Both qualitative and quantitative agreement with the existing experimental database are demonstrated. Flow visualization is instructive for understanding the physics of this flowfield. Author

A88-37210* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL INVESTIGATION OF A JET IN GROUND EFFECT WITH A CROSSFLOW
W. R. VAN DALSEM, A. G. PANARAS, and J. L. STEGER (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 433-445. refs
(SAE PAPER 872344)

One of the flows inherent in V/STOL operations, the jet in ground effect with a crossflow, is studied using the Fortified Navier-Stokes (FNS) scheme. Through comparison of the simulation results and the experimental data, and through the variation of the flow parameters (in the simulation) a number of interesting characteristics of the flow have been observed. For example, it appears that the forward penetration of the ground vortex is a strong inverse function of the level of mixing in the ground vortex. An effort has also been made to isolate issues which require additional work in order to improve the numerical simulation of the jet in ground effect flow. The FNS approach simplifies the simulation of a single jet in ground effect, but will be even more effective in applications to more complex topologies. Author

A88-37211
TURBULENCE AND FLUID/ACOUSTIC INTERACTION IN IMPINGING JETS
ROBERT E. CHILDS and DAVID NIXON (Nielsen Engineering and Research, Inc., Mountain View, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 447-458. refs
(Contract F49620-85-C-0055)
(SAE PAPER 872345)

Enhanced turbulence in an upwash fountain and fluid/acoustic resonance of an impinging axisymmetric jet are investigated by numerical simulations of the mean flow and the largest scales of the unsteady fluid motion. In the planar upwash, the simulated shear stress and spreading rate are three times greater than in a normal jet and are in good agreement with experimental data. Reynolds-stress transport mechanisms which lead to the enhanced turbulence are discussed, and a qualitative description of the large scale turbulent motions is proposed. A model for the pressure-strain term is determined to be a major source of error in Reynolds-stress transport modeling of the upwash. In an axisymmetric impinging jet at a jet Mach number of 0.9, resonant-like behavior with elevated levels of pressure fluctuations and dominance of a single frequency of vortex generation are observed. Vortex stretching is observed to be critical to the generation of noise in the impingement zone. Author

A88-37212
NUMERICAL SIMULATION OF COMPRESSIBLE FLOW FIELD ABOUT COMPLETE ASKA AIRCRAFT CONFIGURATION
SUSUMU TAKANASHI (National Aerospace Laboratory, Chofu, Japan) and KEISUKE SAWADA (Kawasaki Heavy Industries, Ltd., Aircraft Engineering Div., Kobe, Japan) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 459-466. refs
(SAE PAPER 872346)

Numerical simulations of compressible inviscid flows are carried out for the complete configuration of experimental aircraft 'ASKA' which adopts the USB technology to increase the amount of lift force. Three different grid systems corresponding to different configurations are generated by a newly developed interactive grid generation method. Euler equations are solved by the second order upwind biased finite volume method. A planar Gauss-Seidel relaxation method is adopted to realize a rapid convergence to steady solutions. Computations are made to see the influences of different arrangements of engine nacelles over the interfered flow fields. Author

A88-37220* McDonnell-Douglas Research Labs., St. Louis, Mo.
UNSTEADY FEATURES OF JETS IN LIFT AND CRUISE MODES FOR VTOL AIRCRAFT
V. KIBENS, K. R. SARIPALLI, R. W. WLEZIEN, and J. T. KEGELMAN (McDonnell Douglas Research Laboratories, Saint Louis, MO) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 543-552. refs
(Contract NAS3-24621)
(SAE PAPER 872359)

Experiments were performed to simulate jet plume effects associated with VTOL aircraft in takeoff and cruise modes. A water facility was used to investigate the influence of inclination angle and separation distance on the three-dimensional fountain flowfield generated by two impinging jets operating at a jet Reynolds number of 250,000. Substantial differences in the flow features were observed for different spacings between the jets. Plume effects in cruise mode were simulated by a supersonic unheated jet parallel to a wall. Variation of the distance between the wall and the edge of the plume is shown to have a major controlling effect on the supersonic screech instability. Author

A88-37222* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUPERSONIC JET PLUME INTERACTION WITH A FLAT PLATE
JOHN M. SEINER, JAMES C. MANNING (NASA, Langley Research Center, Hampton, VA), and BERNARD JANSEN (Kentron International, Inc., Hampton, VA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 563-573. refs
(SAE PAPER 872361)

Supersonic jet plume interaction with a flat plate was studied using a model scaled test apparatus designed to simulate plume/aircraft structure interaction for the cruise configuration. The generic configuration consisted of a rectangular supersonic nozzle of aspect ratio 7, and a large flat plate located beneath the nozzle at various nozzle plate distances; the plate was instrumented to measure surface dynamic pressure and mean wall temperature, with provisions for measurements of acceleration and strain on coupon size panels that could be inserted in the plate. Phase-averaged schlieren measurements revealed the presence of high-intensity acoustic emission from the supersonic plume above the plate, directed upstream; this radiation could be associated with the shock noise generation. Narrow band spectra of surface dynamic pressure show spectral peaks with amplitude levels reaching 1 psi, related to the screech tones. Temperature measurements indicated elevated surface temperatures in regions of high turbulence intensity. I.S.

A88-37225* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE RSRA/X-WING EXPERIMENT - A STATUS REPORT
JAMES W. LANE and MARK SUMICH (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 597-625. refs
(SAE PAPER 872371)

This paper reports on the current status of the NASA/Army Rotor Systems Research Aircraft (RSRA)/X-Wing Experiment program designed to demonstrate the technology readiness of the X-Wing concept for a prototype vehicle. Program accomplishments, test results on all of the necessary major hardware elements, and the results of flight tests are described. Future wind tunnel testing of the full-scale rotor system in the NASA NF SAC facility is presently being planned; these tests must be completed before an objective assessment can be made regarding the viability of the RSRA/X-Wing concept for an operational aircraft. I.S.

A88-37235* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WAVE DRAG AND HIGH-SPEED PERFORMANCE OF SUPERSONIC STOVL FIGHTER CONFIGURATIONS
DONALD A. DURSTON (NASA, Ames Research Center, Moffett Field, CA) and RONALD K. STONUM (USAF, Washington, DC) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 735-751. refs
(SAE PAPER 872311)

A supersonic STOVL fighter aircraft aerodynamic research program is being conducted at NASA Ames Research Center. The research focuses on technology development for this type of aircraft and includes generating an extensive aerodynamic database and resolving particular aerodynamic uncertainties for various twin- and single-engine aircraft concepts. Highlights of the results from this program are presented. The highlights include propulsion-induced effects on the aircraft drag, prediction capabilities, volume integration for minimizing drag, and wave drag and aerodynamic efficiency comparisons. Results indicate that estimated STOVL fighter performance is roughly comparable to the performance of modern conventional fighters in terms of wave drag and aerodynamic efficiency. Author

A88-37236* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF EMPIRICAL AND LINEAR METHODS TO VSTOL POWERED-LIFT AERODYNAMICS
RICHARD MARGASON (NASA, Ames Research Center, Moffett Field, CA) and RICHARD KUHN IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 753-783. Previously announced in STAR as N88-17581. refs
(SAE PAPER 872341)

Available prediction methods applied to problems of aero/propulsion interactions for short takeoff and vertical landing (STOVL) aircraft are critically reviewed and an assessment of their strengths and weaknesses provided. The first two problems deal with aerodynamic performance effects during hover: (1) out-of-ground effect, and (2) in-ground effect. The first can be evaluated for some multijet cases; however, the second problem is very difficult to evaluate for multijets. The ground-environment effects due to wall jets and fountain flows directly affect hover performance. In a related problem: (3) hot-gas ingestion affects the engine operation. Both of these problems as well as jet noise affect the ability of people to work near the aircraft and the ability of the aircraft to operate near the ground. Additional problems are: (4) the power-augmented lift due to jet-flap effects (both in- and out-of-ground effects), and (5) the direct jet-lift effects during short takeoff and landing (STOL) operations. The final problem: (6) is the aerodynamic/propulsion interactions in transition between hover and wing-borne flight. Areas where modern CFD methods can provide improvements to current computational capabilities are identified. Author

A88-37353* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CALCULATION OF EXTERNAL-INTERNAL FLOW FIELDS FOR MIXED-COMPRESSION INLETS
W. J. CHYU, T. KAWAMURA, and D. P. BENCZE (NASA, Ames Research Center, Moffett Field, CA) (University of Texas, NSF, U.S. Navy, et al., World Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 21-37. Previously announced in STAR as N87-24434. refs

Supersonic inlet flows with mixed external-internal compressions were computed using a combined implicit-explicit (Beam-Warming-Steger/MacCormack) method for solving the three-dimensional unsteady, compressible Navier-Stokes equations in conservation form. Numerical calculations were made of various flows related to such inlet operations as the shock-wave intersections, subsonic spillage around the cowl lip, and inlet started versus unstarted conditions. Some of the computed results were compared with wind tunnel data. Author

A88-37355* Old Dominion Univ., Norfolk, Va.
FLOW SOLUTION ON A DUAL-BLOCK GRID AROUND AN AIRPLANE
LARS-ERIK ERIKSSON (Old Dominion University, Norfolk, VA) (University of Texas, NSF, U.S. Navy, et al., World Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 79-93. refs
(Contract NAG1-363)

The compressible flow around a complex fighter-aircraft configuration (fuselage, cranked delta wing, canard, and inlet) is simulated numerically using a novel grid scheme and a finite-volume Euler solver. The patched dual-block grid is generated by an algebraic procedure based on transfinite interpolation, and the explicit Runge-Kutta time-stepping Euler solver is implemented with a high degree of vectorization on a Cyber 205 processor. Results are presented in extensive graphs and diagrams and characterized in detail. The concentration of grid points near the wing apex in the present scheme is shown to facilitate capture of the vortex generated by the leading edge at high angles of attack and modeling of its interaction with the canard wake. T.K.

A88-37356
SIMULATION OF TRANSONIC FLOW IN RADIAL COMPRESSORS
LARS-ERIK ERIKSSON (Norges Tekniske Hogskole, Trondheim, Norway) (University of Texas, NSF, U.S. Navy, et al., World Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 95-111. Research supported by the Norges Teknisk-Naturvitenskapelige Forskningsrad and Norges Tekniske Hogskole. refs

A collection of computer codes for the generation of grids and the solution of the Euler equations have been developed for the purpose of simulating the complex three-dimensional transonic and rotational flow through high pressure ratio radial compressors. The grid generation procedure is based on transfinite interpolation and generates smooth grids of H-, C-, and O-type with a minimum of operations. The Euler solution procedure is based on a centered finite volume scheme with explicit Runge-Kutta time integration and absorbing inflow/outflow boundary conditions. An example solution for a high-speed radial compressor with a total pressure ratio of 1:12 demonstrates that the method is robust and preserves both mass and rothalpy through strong shocks. It also demonstrates that shock-induced separations with reverse flow can be captured by the numerical procedure. Author

A88-37358
RECENT DEVELOPMENTS AND ENGINEERING APPLICATIONS OF THE VORTEX CLOUD METHOD
R. I. LEWIS (Newcastle-upon-Tyne, University, England) (University of Texas, NSF, U.S. Navy, et al., World Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 153-176. refs

Following a brief summary of the vortex cloud (VC) method, a comparison of two models is made for the case of flow past an isosceles triangular wedge. On the basis of reasonable agreement between these methods a hybrid method has been developed, combining potential flow over the upper surface with sharp edge separation and full VC theory over the lower and rear surfaces. Success for the wedge flow confirms the suitability of this method to air-foils for which the upper surface is prone to 'numerical separation' by full VC theory. Application of the hybrid method to NACA 0025 with an airbrake flap results in considerable improvement of predicted surface pressure, lift coefficient, and drag coefficient. Author

A88-37360
A COMPARISON OF NUMERICAL ALGORITHMS FOR UNSTEADY TRANSONIC FLOW
W. A. SOTOMAYER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), L. N. SANKAR (Georgia Institute of Technology, Atlanta), and J. B. MALONE (Lockheed-Georgia Co., Marietta) (University of Texas, NSF, U.S. Navy, et al., World Congress on Computational Mechanics, 1st, Austin, TX, Sept. 22-26, 1986) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, p. 237-265. Research supported by the Boeing Military Airplane Co. and Lockheed-Georgia Co. refs
(Contract AF-AFOSR-77-3233; AF-AFOSR-79-0023; F33615-83-C-3215)

The steady and unsteady transonic flow over an F-5 wing model is investigated by means of numerical simulations, comparing the performance of the potential codes XTRAN3S (Borland et al., 1980) and USIPWING (Sankar et al., 1981) with that of the Euler code of Sankar et al. (1985). The mathematical derivations of the methods are reviewed, and the results are presented in extensive graphs and characterized in detail with reference to published experimental data. On the clean wing, all three methods gave good results except at M = 0.95 and f = 20 Hz, where a spurious aft shock pulse was predicted. Good agreement was also obtained in simulations with deflected trailing-edge control surfaces and simulations of angle-of-attack effects. T.K.

A88-37653
NUMERICAL SEPARATION MODELS [CHISLENNYE MODELI SRYVA]
O. M. BELOTSERKOVSKII IN: Problems of turbulent flows. Moscow, Izdatel'stvo Nauka, 1987, p. 32-56. In Russian. refs

Some current problems in aerodynamics are studied by direct numerical analysis using full models, without resorting to semiempirical theories. Emphasis is placed on separation (turbulent) flows in the case of 'limiting' regimes at large Reynolds numbers. New numerical models are developed for this class of flows, and numerical methods are proposed for computer implementation. Ordered structures typical of different classes of turbulent flows are shown. V.L.

A88-37657
TURBULENT FRICTION ON A DELTA WING [TURBULENTNOE TRENIE NA TREUGOL'NOM KRYLE]
A. D. KHON'KIN, A. F. KISELEV, and P. P. VOROTNIKOV IN: Problems of turbulent flows. Moscow, Izdatel'stvo Nauka, 1987, p. 80-87. In Russian. refs

Experimental data are presented on statistical pressure distribution, friction resistance, and limiting flow line directions on the leeside of a delta wing of small aspect ratio at large angles of attack under conditions of flow separation at the leading edge. Based on the measurements and result of flow visualization, the flow separation and reattachement lines are determined, as are regions of sharp changes in the boundary layer characteristics. The physical picture of flow on the leeside of the wing is reconstructed for relatively large angles of attack. V.L.

A88-37665
AXISYMMETRIC TURBULENT COMPRESSIBLE JET IN SUBSONIC COFLOW [OSESIMMETRICHNAIA TURBULENTNAIA SZHIMAEMAIA STRUIA V DOZVUKOVOM SPUTNOM POTOKE]
V. E. KOZLOV, A. N. SEKUNDOV, and I. P. SMIRNOVA IN: Problems of turbulent flows. Moscow, Izdatel'stvo Nauka, 1987, p. 171-177. In Russian. refs

Results of an experimental and analytical study of an axisymmetric turbulent compressible air jet in a subsonic comoving stream are reported. Experimental data are obtained on distributions of axial velocity and characteristic thickness along the axis of a submerged supersonic jet for different internal-to-external pressure ratios. An analysis is carried out for a supersonic nonisobaric jet propagating in a subsonic comoving stream. V.L.

A88-37697
SEPARATION OF A SUPERSONIC BOUNDARY LAYER AHEAD OF THE BASE OF A BODY [OTRYV SVERKHZVUKOVOGO POGRANICHNOGO SLOIA PERED DONNYM SREZOM KONTURA TELA]
M. A. KRAVTSOVA and A. I. RUBAN Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 28, April 1988, p. 580-590. In Russian. refs

The separation of supersonic flow near a corner point on a body is analyzed in the context of the asymptotic theory of the interaction between a laminar boundary layer and the external nonviscous part of flow. Particular attention is given to the transition stage of flow during which a pressure increase in the base region leads to the detachment of the separation point from the corner point and to the displacement of the separation point toward the leading edge of the body. Results of a numerical solution are presented. V.L.

A88-37919*# Old Dominion Univ., Norfolk, Va.
AN EXPERIMENTAL INVESTIGATION OF THE AERODYNAMIC CHARACTERISTICS OF SLANTED BASE OGIVE CYLINDERS USING MAGNETIC SUSPENSION TECHNOLOGY
C. P. BRITCHER (Old Dominion University, Norfolk, VA) and C. W. ALCORN IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 117-127. refs
(Contract NAG1-716)
(AIAA PAPER 88-2011)

This paper reports on an experimental investigation of aerodynamic characteristics of slanted base ogive cylinders at zero incidence. The Mach number range is 0.05 to 0.3. In this investigation, magnetically suspending the wind tunnel models eliminates flow disturbances associated with mechanical supports. This paper reports on the drastic changes in lift, pitching moment, and drag for a slight change in base slant angle. Flow visualization with liquid crystals and oil is used to observe base flow patterns responsible for the sudden changes in aerodynamic characteristics. This paper also reports on hysteretic effects that are present and discusses computational results using VSAERO and SANDRAG. Author

A88-37931#
CALCULATED VISCOUS EFFECTS ON AIRFOILS AT TRANSONIC SPEEDS
D. W. SINCLAIR (Calspan Corp., Arnold AFB, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 242-247. refs
(AIAA PAPER 88-2027)

With available computational techniques, the effect of model scale and boundary-layer transition location on pressure distribution and boundary layer properties is demonstrated. The computational techniques are described, in addition to the methods used to estimate transition location and to model the transition zone. Results for two different wing configurations are presented to illustrate the influence of the presence of the boundary layer on the aerodynamic coefficients and shock location at transonic speeds. Author

A88-37932*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VELOCITY PROFILE SIMILARITY FOR VISCOUS FLOW DEVELOPMENT ALONG A LONGITUDINALLY SLOTTED WIND-TUNNEL WALL
JOEL L. EVERHART and SURESH H. GORADIA (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 257-268. refs
(AIAA PAPER 88-2029)

A discussion of the flow field measurements on the slot centerline of two different longitudinally slotted wind-tunnel walls is presented. The longitudinal and transverse components of these data are then transformed using the concept of flow similarity to demonstrate the applicability of the technique to the development of the viscous shear flow along and through a slotted wall. Results are presented showing the performance of the similarity transformations with variations in tunnel station, Mach number, and airfoil-induced curvature of the tunnel free stream. Author

A88-37933#
AERODYNAMIC LAG OF A CLOSE-COUPLED CANARD AIRCRAFT MODEL AT MACH 0.3 TO 1.6
T. D. BUCHANAN and R. W. CAYSE (Calspan Corp., Arnold AFB, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 269-281. refs
(AIAA PAPER 88-2030)

The unsteady loads generated by canard motions on a close-coupled canard aircraft were studied by wind tunnel tests on a scale model of the X-29; these unsteady aerodynamics effects were characterized by the difference in time between the canard motion and the response of the aircraft, or 'lag time'. The tests were performed at Mach 0.3, 0.6, 0.9, and 1.6, at a nominal Reynolds number of 2.0 million/foot and at alpha ranging over a 2-10 deg range at zero and 6-deg yaw angles. Lag times at various frequency ranges were deduced from frequency analyses of the measurement probe outputs; they were 2 msec for canard frequencies in the 30-50 Hz range, and 20 msec for frequencies below 10 Hz. O.C.

A88-37937*# Douglas Aircraft Co., Inc., Long Beach, Calif.
AN EXPERIMENTAL INVESTIGATION OF FLOWFIELD ABOUT A MULTIELEMENT AIRFOIL
A. NAKAYAMA (Douglas Aircraft Co., Aerodynamics Research and Technology Group, Long Beach, CA), H.-P. KREPLIN (Aerodynamische Versuchsanstalt, Goettingen, Federal Republic of Germany), and H. L. MORGAN (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 311-320. refs
(AIAA PAPER 88-2035)

Detailed measurements of mean-flow and turbulence quantities around a multielement airfoil model have been made using pressure and hot-wire probes. The results obtained in two test cases at the chord Reynolds number of 3 million and the freestream Mach number of 0.2 show a number of features of the complex flows that are important in accurate modeling of these flows by numerical methods. Many parts of the shear flow vastly deviate from classical flows, and the interaction with the external potential flow is very strong. Author

A88-38167
ON THE PROSPECTS FOR INCREASING DYNAMIC LIFT
D. G. MABEY (Royal Aircraft Establishment, Dynamics Laboratory, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, March 1988, p. 95-106. refs

A review is given of some recent research, mainly at low speeds, into the development of dynamic lift. Sudden movement of aerodynamic surfaces can generate dynamic lift due to the transient development of separated flow. These dynamic effects are large and well established for aerofoils. They are considered likely to be small for highly swept wings and negligible for slender wings, but there is little experimental evidence to support this inference. The dynamic lift might be increased if conventional sinusoidal motions can be replaced by appropriate periodic saw-tooth motions. The control of large-scale flow separations by rapid movements of aerodynamic surfaces requires further investigation to resolve some of the controversial issues raised in the review. Author

A88-38177#
APPLICATION OF EFFICIENT ITERATION SCHEME AF2 TO COMPUTATIONS OF TRANSONIC FULL-POTENTIAL FLOWS OVER WING-BODY COMBINATIONS
MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A11-A18. In Chinese, with abstract in English. refs

The flow region around the wing-body combination is transformed by local Joukowski transformation into the one around a wing alone for the case with the body of circular cross section. The body-fitted 'O' mesh around the transformed wing alone is constructed for each grid section by numerical conformal mapping, and is then transformed back to form 3-D bodyfitted mesh around the given wing-body combination. The transonic flow computation is performed by the use of a conservative full-potential equation with exact boundary conditions and the efficient iteration scheme in finite difference method AF2. It is shown that only a few changes are needed to expand the computer program for wing alone to cover wing-body combinations. The presented method is limited to the combinations which consist of the bodies of finite or infinite lengths with curved axes and circular cross sections, and the wing of arbitrary planform with finite wing tip. Author

A88-38185#
EXPERIMENTAL INVESTIGATION ON RIGID HOLLOW HEMISPHERICAL PARACHUTE MODEL IN ACCELERATING AND STEADY FLOW
QIXIANG LIAN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) and MINXUAN ZHOU (Nanjing, Hongguang Aero-Dropping Equipment Factory, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A84-A90. In Chinese, with abstract in English. refs

The flow around hollow hemisphere models was investigated in water channel by hydrogen bubble technique. The flow velocity distribution both in front of and behind the model was measured by hydrogen bubble time lines. It is close to the values estimated by the irrotational flow theory for the flow right after the start. As the starting vortex grew larger, the flow in the wake is quite different. A large reversed flow is induced behind the model. Hence, the apparent mass estimated by irrotational flow can only be at the beginning. It should be much larger as the starting vortex becomes larger. Sometimes a large vortex in front of model may be formed in the steady flow. This vortex is unstable and may cause side force and unstable motion to a parachute. This vortex can be reduced and even be eliminated by holes suitably placed on the model. Author

A88-38186#
LINEAR DYNAMICS OF SUPERSONIC INLET
YANSHEN GUAN, XIN YANG, and ZUO KU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A91-A96. In Chinese, with abstract in English. refs

This paper presents a linear mathematical model and method of digital simulation for supersonic inlet dynamics. A simplified steady-state mathematical model and a linear dynamic model of supersonic inlets are combined into an integral one. The latter can be used to calculate directly the steady-state characteristics and to simulate the linear dynamic behavior of both axisymmetrical and two-dimensional supersonic inlets under certain operating conditions. The simulated dynamic responses of a NASA 48 cm axisymmetrical and a NASA 2200 cm two-dimensional supersonic inlets are in good agreement with experimental data. C.D.

A88-38188#
THE CHARACTERISTICS OF ASYMMETRIC VORTICES AND SIDE FORCES ON A SHARP-NOSED BODY WITH WING AND VERTICAL TAIL
NANQIAN CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Feb. 1988, p. B11-B16. In Chinese, with abstract in English.

The variations of side force C(z) vs angles of attack alpha on the wing-body combination and wing-body-vertical tail combination are similar to that on the body-alone at high angles of attack with zero side-slip. They are also similar to that of C(z) vs alpha on the wing-body combination at high angles of attack with beta between -8 and +8 deg. Three kinds of strakes are found to be highly effective on alleviating asymmetric vortices, as well as induced side forces on the body, wing-body-vertical tail combinations with zero side-slip and high angles of attack. Author

A88-38303#
IMPROVEMENTS ON ACCURACY AND EFFICIENCY FOR CALCULATION OF TRANSONIC VISCOUS FLOW AROUND AN AIRFOIL
YI-YUN WANG and TOSHI FUJIWARA (Nagoya University, Japan) Nagoya University, Faculty of Engineering, Memoirs (ISSN 0027-7657), vol. 39, no. 1, 1987, p. 180-193. refs

Several improvements to the procedure of calculating transonic flows around an airfoil are proposed. These include the use of the Beam-Warming implicit factorization scheme, the use of an LU-decomposition to avoid inverting block triangular matrices, and the use of local time step to reach a steady solution. The use of a mixed nonlinear dissipation is shown to enhance shock resolution, while the bundary treatment of like-characteristics improve accuracy and reliability. To demonstrate the improvements, calculations are carried out for the RAE 2822 airfoil at Mach 0.75 and angle of attack 3.19 deg. V.L.

A88-38343
FLOW ANALYSIS AROUND AIRCRAFT BY VISCOUS FLOW COMPUTATION
TADAYUKI TANIOKA, TAKESHI KAIDEN, JUNICHI MIYAKAWA, and MIHO SHIMIZU (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Japan) Mitsubishi Heavy Industries Technical Review (ISSN 0026-6817), vol. 25, Feb. 1988, p. 50-56. refs

Viscous flow computation CFD techniques numerically solve the Navier-Stokes equations on the basis of aircraft geometry boundary conditions. Novel digital simulations employing these methods are expected to be fully equivalent to wind tunnel tests. Attention is presently given to the preprocessing, flow computation, and data-display phases of these CFD methods, for the cases of a transonic airfoil, a transonic airfoil with aileron, interference between lifting surfaces, and a three-dimensional wing-body configuration. O.C.

A88-38376*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL STUDY OF THE SKIN FRICTION ON A SPHEROID AT INCIDENCE
M. ROSENFELD, ED. (NASA, Ames Research Center, Moffett Field, CA; Technion - Israel Institute of Technology, Haifa), M. ISRAELI, ED., and M. WOLFSHTEIN, ED. (Technion - Israel Institute of Technology, Haifa) (Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Collection of Papers, p. 171-180) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 129-136. Research supported by the Stiftung Volkswagenwerk. Previously cited in issue 14, p. 2104, Accession no. A87-35020. refs

A88-38377*# Notre Dame Univ., Ind.
VISUALIZATION AND WAKE SURVEYS OF VORTICAL FLOW OVER A DELTA WING
F. M. PAYNE, T. T. NG, R. C. NELSON (Notre Dame, University, IN), and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 137-143. Research supported by the University of Notre Dame. Previously cited in issue 07, p. 833, Accession no. A86-19817. refs
(Contract NAG2-258)

A88-38775* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THEORETICAL AND EXPERIMENTAL ANALYSIS OF THE SLOTTED-WALL FLOW FIELD IN A TRANSONIC WIND TUNNEL
JOEL L. EVERHART (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 5-8, 1987. 20 p. refs
(SAE PAPER 871757)

The flow in the vicinity of a longitudinally slotted wind-tunnel wall is theoretically analyzed, and equations describing the pressure drop across the wall are derived. The ideal form of the slotted-wall boundary condition is shown to effectively model the wall pressure drop upstream of the point of maximum model thickness providing that a zero-shift correction to the reference pressure is included in the analysis. The wall-pressure drop equations can be linearized by subtracting the tunnel-empty boundary condition. Good correlation is obtained between experimental and theoretical values for variations in Mach number and angle of attack. R.R.

A88-38847
ANALYTICAL STUDY OF FRICTION AND HEAT TRANSFER IN THE VICINITY OF A THREE-DIMENSIONAL CRITICAL POINT AT LOW AND MODERATE REYNOLDS NUMBERS [ANALITICHESKOE ISSLEDOVANIE TRENIIA I TEPLOOBMENA V OKRESTNOSTI TREKHMERNOI KRITICHESKOI TOCHKI PRI MALYKH I UMERNNYKH CHISLAKH REINOL'DSA]
I. G. BRYKINA and V. V. RUSAKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Mar.-Apr. 1988, p. 143-150. In Russian. refs

Hypersonic three-dimensional flow of a viscous gas past blunt bodies at low and moderate Reynolds numbers is investigated analytically with allowance for slip effects and a temperature discontinuity at the surface. Equations of a three-dimensional viscous shock layer are solved by the integral method of successive approximations and by the finite difference method near the critical point. An analytical solution to the problem is obtained to a first approximation. An analysis of the solution yields a simple formula which reduces the calculation of heat flux toward a three-dimensional critical point to the calculation of heat flux toward an axisymmetrical critical point. V.L.

A88-38925* Analytical Services and Materials, Inc., Hampton, Va.
BOUNDARY-LAYER STABILITY ANALYSIS OF NLF AND LFC EXPERIMENTAL DATA AT SUBSONIC AND TRANSONIC SPEEDS
SCOTT A. BERRY (Analytical Services and Materials, Inc., Hampton, VA), J. RAY DAGENHART, ROBERT B. YEATON (NASA, Langley Research Center, Hampton, VA), and JEFFREY K. VIKEN (Complere, Inc., Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 5-8, 1987. 12 p. refs
(SAE PAPER 871859)

NASA-Lewis has conducted wind tunnel experiments to ascertain the effectiveness of state-of-the-art in natural laminar flow (NLF) and LFC airfoils for subsonic and transonic speeds, such as the NLF(1)-0414F and the SCLFC(1)-0513F. Attention is given to the effects of Tollmien-Schlichting (TS) and/or crossflow linear mechanisms amplifying small disturbances to generate turbulence. It is found that the incompressible TS transitional n-factors were generally in the 9-12 range, in agreement with earlier correlation studies; the TS instability was the dominant instability mode on a swept-planform LFC airfoil over the entire range of test conditions. O.C.

A88-38950* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THEORETICAL INVESTIGATIONS, AND CORRELATIVE STUDIES FOR NLF, HLFC, AND LFC SWEPT WINGS AT SUBSONIC, TRANSONIC AND SUPERSONIC SPEEDS
S. H. GORADIA, P. J. BOBBITT, J. C. FERRIS, and W. D. HARVEY (NASA, Langley Research Center, Hampton, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 5-8, 1987. 24 p. refs
(SAE PAPER 871861)

Attention is given to the results of theory/experiment-correlation studies for natural laminar flow, LFC, and hybrid-LFC airfoils at subsonic and supersonic Mach numbers. The method of characteristics, integral compressible boundary layer methods for infinitely swept wings, and a method for prediction of separating turbulent boundary layer characteristics. The integral boundary layer methods are found to be successful at predicting both transonic and supersonic transition phenomena. Computations for wings with 0-50 deg sweep angle, Reynolds number range of 1-30 million, and with and without LFC, are in good agreement with experimental data. O.C.

A88-38976#
PIEZO-ELECTRIC FOILS AS A MEANS OF SENSING UNSTEADY SURFACE FORCES ON FLOW-AROUND BODIES
W. NITSCHE, P. MIROW (Berlin, Technische Universitaet, Federal Republic of Germany), and J. SZODRUCH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 6-2-1 to 6-2-7. Research supported by the Technische Universitaet Berlin, BMFT, and DFG. refs

The experimental determination of steady as well as of unsteady surface-forces on flow-around bodies belongs to the elementary problems in experimental fluid dynamics, e.g. in experimental aircraft aerodynamics. Up to now, experiments on unsteady forces such as pressure or shear fluctuations are performed by means of special plug-like probes (e.g. miniature pressure transducers). An alternative and attractive technique of monitoring unsteady surface forces has become possible through the development of piezoelectric foils. With this novel type of sensor, which can be simply glued on a surface, the piezoelectric effect of polarized plastic foils is used to register time dependent pressure or shear loads on flow-around bodies. First of all, the paper concentrates on the fundamentals of this new measuring technique. Furthermore, some practical applications in experimental aerodynamics are outlined. Author

A88-38984#
COMPUTATIONAL STUDY OF THE UNSTEADY FLOW DUE TO WAKES PASSING THROUGH A CHANNEL
B. SCHOENUNG, R. R. MANKBADI, and W. RODI (Karlsruhe, Universitaet, Federal Republic of Germany) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 8-1-1 to 8-1-6. Research supported by the Forschungsvereinigung Verbrennungskraftmaschinen. refs

The flow in and the heat transfer to turbine cascades are influenced strongly by rotor-stator interaction causing wakes from the preceding row to pass through the cascade channel. Predictions of this unsteady flow are presented for the idealized case of a plane channel with the wakes generated by cylinders moving past the inlet plane. The calculations are obtained with an unsteady finite-volume method employing the k-epsilon turbulence model. The calculation procedure is verified first for developing steady channel flow and is then applied to the unsteady passing wake situation for various moving cylinder-channel configurations. The results show that the passing wakes cause much stronger velocity fluctuations than would be due to turbulence. Author

A88-38985*# Stanford Univ., Calif.
PROPERTIES OF A HALF-DELTA WING VORTEX
RABINDRA D. MEHTA (Stanford University, CA) and ELIZABETH R. CANTWELL (NASA, Ames Research Center, Moffett Field, CA) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 8-3-1 to 8-3-6. refs
(Contract NCC2-294)

The mean flow and turbulence structure of a single longitudinal vortex generated by a half-delta wing placed at a small angle of attack were investigated. Particular consideration was given to the near-field properties of the generator in order to establish the role of the generator wake in the initial rolling-up of the vortex, as well as to the far-field properties so that the approach to equilibrium could be studied. Measurements were made on fine cross-plane grids at seven streamwise locations using hot cross wires. The results show that the point of maximum vorticity and the generator wake do not merge until a streamwise distance equivalent to three generator heights is reached. Comparison with previous data on vortices produced by double-branched generators confirmed that the present vortex had achieved a fully developed state, and at a relatively short streamwise distance. I.S.

A88-38986#
LDV MEASUREMENTS ON IMPINGING TWIN-JET FOUNTAIN FLOWS WITH A SIMULATED FUSELAGE UNDERSURFACE
K. R. SARIPALLI (McDonnell Douglas Research Laboratories, Saint Louis, MO) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 8-4-1 to 8-4-8. refs

This paper describes the characteristics of an axisymmetric twin-jet fountain flow in the presence of a simulated fuselage undersurface which simulated the twin-jet configuration of an AV-8B VTOL aircraft. The experiments included flow visualization studies and LDV measurements. Two distinct flow regimes were identified: (1) an isolated fountain region where both the mean velocity and turbulence quantities exhibit self-similarity, and the spread and decay of the fountain are linear; and (2) an interactive fountain region where the upwash flow interacts with the fuselage undersurface and the source jets, thus forming strong recirculation zones. I.S.

A88-38987#
MEASUREMENTS OF TURBULENT FLOW BEHIND A WING-BODY JUNCTION
OKTAY OZGAN and SEMIH OLCMEN (Istanbul Technical University, Turkey) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 8-5-1 to 8-5-5. refs

An experimental investigation of the turbulent shear flow behind a wing-flat plate junction is reported. Presented data include skin-friction lines and coefficient, static pressure coefficient and mean velocity components. A secondary separation line and a single tornado vortex were observed on the flat plate downstream of the wing. Velocity measurements revealed a complex vortical flow structure which was consistent with a proposed mean streamline pattern in the cross-flow plane. Author

A88-38988#
TIME-DEPENDENT STRUCTURE IN WING-BODY JUNCTION FLOWS
WILLIAM J. DEVENPORT and R. L. SIMPSON (Virginia Polytechnic Institute and State University, Blacksburg) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 8-6-1 to 8-6-8. refs
(Contract N60921-83-C-A165-B02)

The time-dependent and time averaged features of a wing-body junction flow formed around a cylindrical wing with a 1.5:1 elliptical nose and NACA 0020 tail are being studied. In this paper, velocity and skin friction measurements made in the nose region are presented and discussed. These measurements show that a coherent junction vortex is a feature of both the instantaneous and time-mean flows. Away from the wing fluctuations in the instantaneous size and position of this vortex produce bimodal (double-peaked) histograms of velocity fluctuations. Adjacent to the wing this vortex appears to be associated with a region of laminarescent flow. Author

A88-39000#
MEASUREMENTS IN A THREE-DIMENSIONAL TURBULENT BOUNDARY-LAYER
OKTAY OZCAN (Istanbul Technical University, Turkey) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 11-1-1 to 11-1-6. refs

An experimental study of a three-dimensional, pressure-driven, attached turbulent boundary-layer flow was made at Mach 0.4. Both the mean velocities and the full Reynolds stress tensor were measured simultaneously by a three-component LDA system. Favorable and adverse streamwise and azimuthal pressure gradients existed on the swept-bump model which simulated the highly three-dimensional boundary-layer flow on a swept wing. The streamwise distance measured from the bump leading edge was observed to be a correlation parameter for all mean flow quantities. Several assumptions used for turbulence modeling of three-dimensional boundary-layers were checked for their validity in this flow. Author

A88-39011*# Imperial Coll. of Science and Technology, London (England).
FLOW IN OUT-OF-PLANE DOUBLE S-BENDS
M. C. SCHMIDT, J. H. WHITELAW (Imperial College of Science and Technology, London, England), and M. YIANNESKIS (King's College, London, England) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 13-3-1 to 13-3-6. refs
(Contract NAGW-747)

An experimental investigation of developing flows through a combination of out-of-plane S-bend ducts was conducted to gain insight into the redirection of flow in geometries similar to those encountered in practical aircraft wing-root intake ducts. The present double S-bend was fabricated by placing previously investigated S-ducts and S-diffusers in series and with perpendicular planes of symmetry. Laser-Doppler anemometry was employed to measure the three components of mean velocity, the corresponding rms quantities, and Reynolds stresses in the rectangular cross-section ducts. Due to limited optical access, only two mean and rms velocity components were resolved in the circular cross-section ducts. The velocity measurements were complemented by wall static pressure measurements. The data indicates that the flows at the exit are complex and asymmetric. Secondary flows generated by the pressure field in the first S-duct are complemented or counteracted by the secondary flows produced by the area expansion and the curvature of the S-diffuser. The results indicate the dominance of the inlet conditions and geometry upon the development of secondary flows and demonstrate that the flows are predominantly pressure-controlled. The pressure distribution caused by the duct geometry determines the direction and magnitude of the bulk flow while the turbulence dictates the mixing characteristics and profiles in the near wall region. Author

A88-39017#
EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE FORMATION AND EVOLUTION OF STREAMWISE VORTICES IN THE PLANE WAKE BEHIND A FLAT PLATE
E. MEIBURG (Stanford University, CA) and J. C. LASHERAS (Southern California, University, Los Angeles, CA) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 16-1-1 to 16-1-6. Research supported by the U.S.-Spain Joint Committee for Scientific and Technological Cooperation. refs

The three-dimensional structure of the vorticity field in a plane wake behind a flat plate is studied both experimentally and numerically. It is shown that under the effect of perturbations initially distributed periodically along the span, the redistribution, reorientation, and stretching of the vorticity in the wake leads to the formation of counter-rotating pairs of streamwise vortices. These streamwise vortices exhibit a lambda-shaped structure and are oriented along the direction of the principal plane of the positive strain field existing in the braids connecting consecutive Karman vortices of opposite sign. Author

A88-39023*# Princeton Univ., N. J.
DETECTION OF LARGE-SCALE ORGANIZED MOTIONS IN A TURBULENT BOUNDARY LAYER
E. M. FERNANDO, E. F. SPINA, J. F. DONOVAN, and A. J. SMITS (Princeton University, NJ) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 16-8-1 to 16-8-6. refs
(Contract AF-AFOSR-85-0126; NAG1-545)

This paper presents and discusses experimental data from an investigation of organized motions in a supersonic turbulent boundary layer. Conditional sampling of crossed-wire and multiple normal-wire signals is performed. A comparison is made between events detected using the VITA conditional sampling technique and those found by thresholding the UV signal. Based on this comparison, limitations of the VITA technique are discussed. The conditional sampling results indicate that most organized motions are consistent with hairpin vortices. Author

A88-39030#

THE CALCULATION OF THE FLOW THROUGH A TWO-DIMENSIONAL FAIRED DIFFUSER

W. P. JONES (Imperial College of Science and Technology, London, England) and A. MANNERS (Rolls-Royce, PLC, Derby, England) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 17-7-1 to 17-7-5. refs

A Reynolds stress transport equation model and the k-epsilon turbulence model have been applied to the calculation of the flow through an annular faired gas turbine diffuser. The results clearly show the superiority of the transport equation model which accurately reproduces the observed features of the flow. These include the influences of curvature associated with the inlet and outlet bends, the recovery from the adverse pressure gradient of the diffusing section and the asymmetric velocity profile in the setting length downstream of the diffuser. None of these is adequately represented by the k-epsilon model. In addition, the velocity profiles predicted by the model are in broad agreement with those measured whereas, with the k-epsilon model, large discrepancies arise. Author

A88-39278

COMPARISON OF EULER AND NAVIER-STOKES SOLUTIONS FOR VORTEX FLOW OVER A DELTA WING

A. RIZZI (Flygtekniska Forsoksanstalten, Bromma; Kungliga Tekniska Hogskolan, Stockholm, Sweden) and B. MUELLER (Flygtekniska Forsoksanstalten, Bromma, Sweden) Aeronautical Journal (ISSN 0001-9240), vol. 92, April 1988, p. 145-153. Research supported by the Styrelsen for Teknisk Utveckling, U.S. Navy, and NSF. refs

A numerical method has been developed recently to solve the Navier-Stokes equations for laminar compressible flow around delta wings. A large-scale Navier-Stokes solution on a mesh of 129 x 49 x 65 points for transonic freestream Mach flow of 0.85, alpha = 10 deg and freestream Reynolds number of 2.38 million around a 65 deg swept delta wing with round leading edge is presented and compared with a correspondingly large-scale Euler solution. The viscous results reveal the presence of primary, secondary, and even tertiary vortices. The starting location of the primary vortex is seen to be quite different in the two solutions. In the viscous solution it starts at the wing apex, but in the Euler results it starts about one quarter chord downstream. The secondary separations are also different, due to the up-lifting of the boundary layer in the viscous results, but to a cross-flow shock in the Euler computation. Comparison with experiment shows that the interaction between the primary and secondary vortices in the Navier-Stokes computation is obtained correctly and that these results are a more realistic simulation than the one given by the Euler equations. Author

A88-39279

PREDICTION OF VORTEX LIFT OF NON-PLANAR WINGS BY THE LEADING-EDGE SUCTION ANALOGY

B. C. HARDY and S. P. FIDDES (Royal Aircraft Establishment, Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, April 1988, p. 154-164. refs

A three-dimensional panel method has been used to calculate edge-suction forces for thin sharp-edged wings in incompressible flow. The suction forces have been used to estimate the vortex lift on the wings by means of the leading-edge suction analogy due to Polhamus. The results for planar wings are in acceptable agreement with other methods based on the suction analogy. A limited comparison with results from experiments for nonplanar wings revealed good prediction of lift and drag increments associated with the deflection of leading and trailing edge flaps for 'conventional' wings of high sweep, but only moderate agreement for a grossly nonplanar configuration. Author

A88-39488

COMPUTATION OF CASCADE FLOW USING A FINITE-FLUX-ELEMENT METHOD [BERECHNUNG DER GITTERSTROEMUNG MIT HILFE EINES FINITEN-FLUSS-ELEMENTE-VERFAHRENS]

S. GRASWALD (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, Mar.-Apr. 1988, p. 111-115. In German. refs

The subdomain FEM procedure developed by Lucchi (1979) and Weber et al. (1984) to solve the conservative full potential equations for transonic plane cascade flow is extended and refined to treat axisymmetric stream surfaces. Particular attention is given to the basic equations, the introduction of the potential, the computational domain and control volume, the form functions, the treatment of density, and the boundary conditions. The numerical implementation of the method is briefly characterized, and typical results are presented in graphs. The present technique permits direct computation of blade profiles without the need for projection onto cylindrical surfaces. T.K.

A88-39511* Lockheed Missiles and Space Co., Sunnyvale, Calif.

FLUID MECHANICS OF DYNAMIC STALL. I - UNSTEADY FLOW CONCEPTS

L. E. ERICSSON and J. P. REDING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Fluids and Structures (ISSN 0889-9746), vol. 2, Jan. 1988, p. 1-33. refs
(Contract NAS1-7999; NAS1-9987)

Advanced military aircraft 'supermaneuverability' requirements entail the sustained operation of airfoils at stalled flow conditions. The present work addresses the effects of separated flow on vehicle dynamics; an analytic method is presented which employs static experimental data to predict the separated flow effect on incompressible unsteady aerodynamics. The key parameters in the analytic relationship between steady and nonsteady aerodynamics are the time-lag before a change of flow conditions can affect the separation-induced aerodynamic loads, the accelerated flow effect, and the moving wall effect. O.C.

A88-39512* Lockheed Missiles and Space Co., Sunnyvale, Calif.

FLUID MECHANICS OF DYNAMIC STALL. II - PREDICTION OF FULL SCALE CHARACTERISTICS

L. E. ERICSSON and J. P. REDING (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Fluids and Structures (ISSN 0889-9746), vol. 2, March 1988, p. 113-143. refs
(Contract NAS1-7999; NAS1-9987)

Analytical extrapolations are made from experimental subscale dynamics to predict full scale characteristics of dynamic stall. The method proceeds by establishing analytic relationships between dynamic and static aerodynamic characteristics induced by viscous flow effects. The method is then validated by predicting dynamic test results on the basis of corresponding static test data obtained at the same subscale flow conditions, and the effect of Reynolds number on the static aerodynamic characteristics are determined from subscale to full scale flow conditions. O.C.

A88-39623

EXPERIMENTAL STUDY OF A SUPERSONIC TURBULENT BOUNDARY LAYER USING A LASER DOPPLER ANEMOMETER

MAX ELENA and JEAN-PAUL LACHARME (Aix-Marseille II, Universite, Marseille, France) Journal de Mecanique Theorique et Appliquee (ISSN 0750-7240), vol. 7, no. 2, 1988, p. 175-190. DRET-supported research. refs

A two-component LDA is used to experimentally study a quasi-equilibrium supersonic turbulent boundary layer, and the measured characteristics of turbulence are compared to hot-wire measurements. Measurements are obtained of velocity fluctuations, Reynolds tangential stresses, skewness and flatness factors, and the intermittency factor, at a freestream Mach number of 2.3. Boundary layer measurements are shown to agree with boundary layer data taking compressibility effects into account. The effect of the injection of light-scattering particles on the LDA results is investigated. R.R.

A88-39952
OBSERVATION OF THREE-DIMENSIONAL 'SEPARATION' IN SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS
S. M. BOGDONOFF (Princeton University, NJ) IN: Boundary-layer separation; Proceedings of the IUTAM Symposium, London, England, Aug. 26-28, 1986. Berlin and New York, Springer-Verlag, 1987, p. 37-55. refs
(Contract F49620-84-C-0086)

Analyses have been conducted of specific two-dimensional and highly swept three-dimensional shock wave and turbulent boundary layer interactions. It is found that three-dimensional flows are drastically different from classical two-dimensional flows; these differences extend to scales, pressure gradients, degree of unsteadiness, and computability. The characterization of phenomena as being of 'separation' is not realistic in three-dimensions. A concept of 'vorticity rearrangement is proposed to describe the physics of three-dimensional interaction. O.C.

A88-39967
SEPARATION AND REATTACHMENT NEAR THELEADING EDGE OF A THIN WING
TUNCER CEBECI, KALLE KAUPS, and A. A. KHATTAB (Douglas Aircraft Co., Long Beach, CA) IN: Boundary-layer separation; Proceedings of the IUTAM Symposium, London, England, Aug. 26-28, 1986. Berlin and New York, Springer-Verlag, 1987, p. 313-330. refs
(Contract F49620-84-C-0007)

An interactive boundary-layer procedure based on a quasi-three-dimensional approximation is used to calculate separation and reattachment near the leading-edge of a thin wing. Results for a given sweep angle show that, as in two-dimensional flows, reverse flow solutions exist only for a limited range of angles of attack above the critical angle at which the non-interactive boundary layer separates. The solutions for the upper branch behave in the same manner as those predicted by the triple-deck theory for marginal separation in two-dimensional flows. The existence of solutions for the lower branch remains to be investigated. Author

A88-39970
EXPERIMENTAL INVESTIGATION OF TOPOLOGICAL STRUCTURES IN THREE-DIMENSIONAL SEPARATED FLOW
H. BIPPES (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Boundary-layer separation; Proceedings of the IUTAM Symposium, London, England, Aug. 26-28, 1986. Berlin and New York, Springer-Verlag, 1987, p. 379-381.

A treatment is presented for that class of three-dimensional separated flows where a system of vortices develops with vortex filaments that are not everywhere aligned to the oncoming flow, so that unsteady flow areas originate. This type of separation appears on a hemisphere cylinder at incidence. An attempt is made to detect and classify the possible topological structures of the class of three-dimensional separated flows thus defined. O.C.

A88-40311
AERODYNAMICS OF SUPERSONIC SHAPES [AERODINAMIKA SVERKHZVUKOVYKH FORM]
ALEKSANDR IVANOVICH SHVETS Moscow, Izdatel'stvo Moskovskogo Universiteta, 1987, 208 p. In Russian. refs

Problems in the aerodynamics of supersonic shapes are examined with reference to recent theoretical and experimental research related to minimum-drag bodies. In particular, attention is given to inverse problems in gas dynamics, methods for calculating flow past bodies of star-like configurations, and principles of the design of star-shaped structures. The discussion also covers wind tunnel test data, physical models of flows, and methods for calculating real structures with allowance for edge bluntness, friction, and heat transfer. V.L.

A88-40314
FACTORS AFFECTING THE TEMPERATURE STATE OF THE BLADING OF HIGH-TEMPERATURE TURBINES [FAKTORY, VLIIAIUSHCHIE NA TEMPERATURNOE SOSTOIANIE LOPATOCHNYKH APPARATOV VYSOKOTEMPERATURNYKH TURBIN]
L. M. ZYSINA-MOLOZHEN (Nauchno-Proizvodstvennoe Ob'edinenie, TsKTI, Leningrad, USSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 10, no. 2, 1988, p. 12-24. In Russian. refs

Recent work concerned with flow mechanisms, turbulence structure, and local heat transfer coefficients in the interprofile passages of turbine blading is reviewed. Particular attention is given to two groups of papers: those dealing with cascades of short blades and the effect of secondary flows on the heat transfer from the profiles and end walls and those dealing with the effect of the guide and rotor blades on flow and heat transfer. The factors to be considered in evaluating the thermal stressed state of blades are identified. V.L.

A88-40375#
HEAT FLUX ON THE SURFACE OF A WEDGE IN MACH REFLECTION AND REGULAR REFLECTION OF SHOCK WAVES
MASANORI HAYASHI, SHIGERU ASO, YOSHIHARU TANAHASHI, and AKIRA YAMASHITA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 61, Jan. 1988, p. 59-65. In Japanese, with abstract in English. refs

Measurements of transient temperature and pressure rise on a surface of wedge in a shock tube have been carried out for the case where the incident oblique shock waves on the surface reflect under the conditions of shock Mach numbers 1.34-2.75, with wedge angles of 35.0-48.0 degrees. The heat flux on the surface has been calculated by using the temperature rise. It is known that there are four patterns for the shock reflections. In this paper, these shock reflection patterns have been visualized by the Schlieren method. Finally, it is shown that each flow pattern exhibits characteristic changes of the surface temperature, heat flux and pressure rise with time, and these variations are influenced by the slipstream. Author

A88-40421#
UNSTEADY AERODYNAMIC HEATING PHENOMENA IN THE INTERACTION OF SHOCK WAVE/TURBULENT BOUNDARY LAYER
MASANORI HAYASHI, SHIGERU ASO (Kyushu University, Fukuoka, Japan), and ANZHONG TAN Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 47, Dec. 1987, p. 231-239. refs

Fluctuations of heat transfer have been measured in the regions of interaction between oblique shock waves and turbulent boundary layers. A new type of heat transfer rate gauge with high spatial resolution and fast response developed in the laboratory was used for the measurements of heat transfer rates. Results are compared with the wall pressure fluctuation measurements performed under the same test conditions. Experiments were made at a nominal Mach number of 4, wall temperature condition of 0.56, and Reynolds number of 1.26 x 10 to the 7th based on the distance from the flat plate leading edge. When the boundary layer is unseparated, fluctuations of heat transfer get strong near the impinging point of the incident shock; however no intermittency phenomena are observed. When the boundary layer is separated, significant fluctuations of heat transfer are observed throughout the interaction region. Near the separation and the reattachment point, the fluctuations are particularly strong, and near the separation point intermittency of heat transfer is observed. Author

A88-40601*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

FLOW VISUALIZATION AND PRESSURE DISTRIBUTIONS FOR AN ALL-BODY HYPERSONIC AIRCRAFT

WILLIAM K. LOCKMAN, SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA), and JOSEPH W. CLEARY (Eloret Institute, Sunnyvale, CA) USAF, National Aero-Space Plane Technology Symposium, 4th, Monterey, CA, Feb. 17-19, 1988, Paper. 27 p. refs

(Contract NCC2-416)

A CFD code-validation effort has been conducted at the NASA-Ames 3.5-ft hypersonic wind tunnel, using a generic, 'all-body' hypersonic aircraft configuration model. The CFD methods to be validated encompass approximate inviscid ones and the upwind parabolized Navier-Stokes solver code. Flow visualizations and pressure distributions are obtained for the cases of zero and 15 deg angles of attack. A complex leeward flow is observed at angle-of-attack with crossflow separation and vortices, and significant changes are noted in the transition from the forebody's conical to the afterbody's nonconical flows. O.C.

A88-40701

AIAA APPLIED AERODYNAMICS CONFERENCE, 6TH, WILLIAMSBURG, VA, JUNE 6-8, 1988, TECHNICAL PAPERS

Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 704 p. For individual items see A88-40702 to A88-40769.

The present conference on applied aerodynamics discusses the flowfield for the propeller disks of a twin-pusher canard configuration, the effects of canard-wing flowfield interactions on longitudinal stability and potential deep-stall trim, the progress of wing vortex flows to vortex breakdown, flow visualization by IR imaging, wind tunnel investigation of wing-in-ground effects, three-dimensional windmill surface pressure calculations, the base drag of highly maneuvering nonthrusting missiles, riblet drag reduction at flight conditions, and calculations of hypersonic transitional flow over cones. Also discussed are the roll characteristics of finned projectiles, the design of low Reynolds number airfoils, a comparative study of vortex structures, three-dimensional hypersonic nonequilibrium flows at large angles-of-attack, the analysis of wing rock due to forebody vortices, and the influence of small surface discontinuities in turbulent boundary layers. O.C.

A88-40702#

THE NUMERICAL SIMULATION OF THE NAVIER-STOKES EQUATIONS FOR AN F-16 CONFIGURATION

GARY W. HUBAND, DONALD P. RIZZETTA, and JOSEPH J. S. SHANG (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1-8. refs

(AIAA PAPER 88-2507)

A numerical solution is presented for the steady-state flow over an F-16A aircraft configuration at a freestream Mach number of 1.2, a Reynold's number of 12.75 million, and an angle-of-attack of six degrees. The three-dimensional Navier-Stokes equations in mass-averaged variables were numerically integrated using the MacCormack (1969) explicit algorithm with an algebraic turbulence model to provide closure of the system of equations. The grid structure, boundary conditions, turbulence model, and solution procedure are discussed in detail for this complex aircraft geometry. The solution is then compared to experimental results in terms of surface pressure coefficients with reasonable agreement. Finally, details of the flow are discussed, such as the strake vortex and the wing vortex structures. Author

A88-40705#

ON A LEAST-ENERGY HYPOTHESIS FOR THE WAKE OF AXISYMMETRIC BODIES WITH TURBULENT SEPARATION - PRESSURE-DISTRIBUTION PREDICTION

FABIO R. GOLDSCHMIED IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 27-39. refs

(AIAA PAPER 88-2513)

It is presently hypothesized that the free-wake development, in such axisymmetric low-speed bodies with turbulent flow separation as Rankine bodies with convex or conical tails, must be such as to minimize energy and momentum losses. A hyperbolic contour is assumed for constant-momentum wake 'displacement afterbodies'; the momentum loss at any axial wake location is given by the Young equation, and the boundary layer-over-body and 'displacement aftbody' are computed by the E7ES algorithm. It is found that the addition of the 'aftbody' to the Rankine body would eliminate the turbulent free wake and generate a steady attached wake. O.C.

A88-40708#

APPLICATIONS OF AN EULER AERODYNAMIC METHOD TO FREE-VORTEX FLOW SIMULATION

P. RAJ, J. M. KEEN, and S. W. SINGER (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 58-72. Research supported by the Lockheed Aeronautical Systems Co. refs

(Contract F33615-84-C-3005)

(AIAA PAPER 88-2517)

A Three-dimensional Euler Aerodynamic Method (TEAM) is used to simulate the interaction of free vortices with lifting surfaces. The free vortices may form due to flow separation along sharp leading edges of slender, swept wings at moderate to high angles of attack or be shed in the wake behind canards or wings. Computed results for a 74-deg delta wing, a 75/62-deg double-delta wing-body, and a canard-wing-body configuration are correlated with experimental data to evaluate TEAM's capabilities. In all cases, the flow is impulsively started and the vortices are automatically captured. Sensitivity of the computed solutions to the treatment of numerical dissipation needed to augment TEAM's cell-centered finite-volume algorithm is investigated. Also, the effect of grid density on computations is shown. The results provide an added measure of confidence in TEAM's abilities in simulating the free-vortex flows, and also point out some of its limitations. Author

A88-40709#

WING VORTEX-FLOWS UP INTO VORTEX BREAKDOWN - A NUMERICAL SIMULATION

STEPHAN M. HITZEL (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 73-83. Research sponsored by the Bundesministerium der Verteidigung. refs

(AIAA PAPER 88-2518)

Leading edge vortex flows, which may dominate the aerodynamics of future military aircraft as well as some civil transports, can be exploited through control of the currently troublesome vortex-breakdown phenomenon. The interaction of shock systems and vortex flows at supersonic speeds will also present important problems that must be anticipated theoretically and treated experimentally. Attention is presently given to the solution of the time-dependent Euler equations in conservation form by means of an explicit finite-volume approach, using such accelerating features as local time-stepping, a multigrid strategy, and enthalpy forcing. O.C.

A88-40712#

FOURTH-ORDER ACCURATE CALCULATIONS OF THE 3-D COMPRESSIBLE BOUNDARY LAYERS ON AEROSPACE CONFIGURATIONS

SAMIR F. RADWAN (Alexandria University, Egypt) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June

6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 110-120. refs
(AIAA PAPER 88-2522)

A fourth-order accurate finite-difference procedure is introduced to compute the compressible viscous flows over configurations with aerodyamic interest, in particular, fuselage-type and wing-type configurations. The first-order 3-D compressible boundary layer equations are written in nonorthogonal surface oriented coordinates and are solved in transformed coordinates. Two-point compact scheme with a fourth-order accuracy is used to solve the governing equations because of its high accuracy or its short computing time. The accuracy of the present method has been checked by computing well-documented test cases. Having done that, the subsonic viscous flowfields of a prolate spheroid and swept wing are computed. Their inviscid flow solutions are generated numerically by solving surface Euler equations. It is found that the present method is stable, efficient, and with a fourth-order accuracy. Therefore, it is recommended to use the present method in the stability analysis of laminar flows or in the viscous/inviscid interacting procedures. Author

A88-40714#
FLOW PAST TWO-DIMENSIONAL RIBBON PARACHUTE MODELS
FUMIYUKI TAKAHASHI and HIROSHI HIGUCHI (Minnesota, University, Minneapolis) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 129-137. Research supported by Sandia National Laboratories. refs
(AIAA PAPER 88-2524)

Aerodynamic characteristics of two-dimensional, slotted bluff bodies were experimentally investigated. Flow visualizations, base pressure measurements, mean velocity vector measurements, and drag force measurements were conducted to analyze effects of spacing ratio (i.e. porosity), curvature, and vent. Low porosity model configurations produced stable near-wake patterns with enhanced vortex sheddings downstream. Model curvature reduced drag forces and weakened the vortex sheddings. Stabilizing effect of curvature on the near-wake patterns was also found. A vent combined with large model curvature was found to control drag force effectively in addition to suppressing the vortex sheddings. Author

A88-40716#
WIND TUNNEL INVESTIGATION OF WING-IN-GROUND EFFECTS
M. D. CHAWLA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), L. C. EDWARDS, and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 147-153.
(AIAA PAPER 88-2527)

Wing-in-ground (WIG) effects from a wind tunnel study of a NACA 4415-airfoil-profile wing model with an aspect ratio of 2.33 are described. The wing model contains a 20-percent-chord, full-span adjustable flap and removable end and center plates. Ground boards are used in the wind tunnel to simulate the ground. In this study the ground effects are expressed as variations to the aerodynamic coefficients (lift and drag) and lift-to-drag ratio. The ground effects are described in terms of angle of attack, flap angle, wing height above ground, and use and size of end and center plates. It is shown that ground effects are diminished as the wing height from the ground is increased. Author

A88-40717#
EXPERIMENTAL AND ANALYTICAL AERODYNAMICS OF AN ADVANCED ROTOR IN HOVER
R. M. HODGES, JR., G. J. CARLIN, JR., and L. DADONE (Boeing Helicopters, Philadelphia, PA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 154-159. refs
(AIAA PAPER 88-2530)

This paper deals with helicopter rotor hover performance and blade pressure data taken at the Duits Nederlandse Wind Tunnel (DNW) during the summer of 1986 and with correlations of analytical predictions with the test data. The model tested is a state-of-the-art Boeing Helicopters Model 360 rotor with second generation transonic airfoils and a tapered-tip planform. Time histories of blade pressures (leading edge and various chordwise positions), blade loads, and blade motions were recorded in conditions ranging from hover to high speed forward flight to provide a comprehensive data base against which analysis tools can be compared. This paper is concerned with the hover portion of the data. Correlations are shown between the data and several analyses including a two-dimensional airfoil analysis to predict chordwise pressure distributions, a lifting line and lifting surface method rotor analysis to predict blade loading, and a semi-empirical leading edge pressure method to predict blade loading. The large volume of high quality data taken at DNW will serve as a comprehensive data base against which analysis tools may be compared. Author

A88-40718*# Flow Research, Inc., Kent, Wash.
OPTIMIZING ADVANCED PROPELLER DESIGNS BY SIMULTANEOUSLY UPDATING FLOW VARIABLES AND DESIGN PARAMETERS
MAGDI H. RIZK (Flow Research, Inc., Kent, WA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 160-167. refs
(Contract NAS3-24855)
(AIAA PAPER 88-2532)

A scheme is developed for solving constrained optimization problems in which the objective function and the constraint function are dependent on the solution of the nonlinear flow equations. The scheme updates the design parameter iterative solutions and the flow variable iterative solutions simultaneously. It is applied to an advanced propeller design problem with the Euler equations used as the flow governing equations. The scheme's accuracy, efficiency and sensitivity to the computational parameters are tested. Author

A88-40728#
NUMERICAL SIMULATION OF WINGS IN STEADY AND UNSTEADY GROUND EFFECTS
D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) and A. O. NUHAIT IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 246-257. refs
(AIAA PAPER 88-2546)

A numerical simulation of steady and unsteady ground effect is developed. The simulation is based on the general unsteady vortex-lattice method, and is not restricted by planform, angle of attack, sink rate, dihedral angle, twist. etc. as long as stall does not occur. The present computed results are generally in close agreement with limited exact solutions and experimental data. The present results show the influences of various parameters on the aerodynamic coefficients for both steady and unsteady flows. Generally, the aerodynamic coefficients increase with proximity to the ground, the greater the sink rates the greater the increases. Increasing the aspect ratio increases both the steady and unsteady ground effects for both rectangular and delta planforms. The steady ground effect increases the rolling moment and the side force. The present results serve to demonstrate the potential of the present approach. Author

A88-40729#
TRANSONIC EULER CALCULATIONS OF A WING-BODY CONFIGURATION USING A HIGH-ACCURACY TVD SCHEME
CHUNG-JIN WOAN (Rockwell International Corp., Los Angeles, CA) and SUKUMAR R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) IN: AIAA Applied

Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 258-268. Research supported by the Rockwell International Independent Research and Development Program. refs
(AIAA PAPER 88-2547)

A high-accuracy TVD Euler solver developed by the second author is used to calculate flowfields of an NACA research-type 45-degree swept wing-fuselage configuration at Mach numbers of 0.9 and 1.2 and an angle of attack of 6 degrees. A unique feature in the present calculation is that the flowfield is partitioned into a series of contiguous blocks, each being a nearly rectangular parallelopiped in shape. A grid of H-type is generated for each block independently of others. For efficiency of flow calculation, these blocked grids are combined into a smaller number of solution blocks. The combined grid has large grid-line slope discontinuities within the blocks and at block interfaces. Calculated results compared with experimental data indicate that the high-accuracy TVD Euler solver can calculate transonic flowfields efficiently and accurately on a such multi-block grid, hence, the flowfield blockings and griddings of realistic aerodynamic configurations can be greatly simplified. Author

A88-40730#
GRID GENERATION AND FLOW ANALYSES FOR WING/BODY/WINGLET CONFIGURATIONS
N. JONG YU, HAI-CHOW CHEN, ALLEN W. CHEN, and K. ROBYN WITTENBERG (Boeing Co., Seattle, WA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 269-275. Research supported by the Boeing Independent Research and Development Program. refs
(AIAA PAPER 88-2548)

A grid generation code together with both full potential and Euler flow analysis codes has been developed for the study of wing/body/winglet configurations. The grid generation code solves a set of elliptic equations to generate the field grids. Both the full potential and the Euler flow codes solve the basic conservation equations of fluid mechanics using a finite volume formulation. A highly efficient multigrid scheme is employed in both the full potential code and the Euler code to insure fast and reliable convergence of the iterative solution procedure. The advantages and the disadvantages of using the full potential code vesus the Euler code for wing/winglet analyses are discussed. Test/theory comparisons show that the Euler code gives better results, even at subcritical flow conditions. Author

A88-40731*# Vigyan Research Associates, Inc., Hampton, Va.
EXPERIMENTAL INVESTIGATION OF NON-PLANAR SHEARED OUTBOARD WING PLANFORMS
D. A. NAIK (Vigyan Research Associates, Inc., Hampton, VA) and C. OSTOWARI (Texas A & M University, College Station) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 276-286. Research supported by Texas A&M University. refs
(Contract NAG1-344)
(AIAA PAPER 88-2549)

The outboard planforms of wings have been found to be of prime importance in studies of induced drag reduction. This conclusion is based on an experimental and theoretical study of the aerodynamic characteristics of planar and nonplanar outboard wing forms. Six different configurations; baseline rectangular, planar sheared, sheared with dihedral, sheared with anhedral, rising arc, and drooping arc were investigated for two different spans. Span efficiencies as much as 20 percent greater than baseline can be realized with nonplanar wing forms. Optimization studies show that this advantage can be achieved along with a bending moment benefit. Parasite drag and lateral stability estimations were not included in the analysis. Author

A88-40732#
WAKE RAKE STUDIES BEHIND A SWEPT SURFACE, CANARD AIRCRAFT
NEAL J. PFEIFFER (Beech Aircraft Corp., Wichita, KS) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 287-292. refs
(AIAA PAPER 88-2552)

A wake rake with 21 five hole probes was flown on a Beech Starship prototype at various locations behind the aft wing, vertical stabilizer, and forward wing. Wind tunnel measurements were made with a single transversing five hole probe to match the flight conditions for the appropriate rake locations. Wake velocity profiles and momentum equation integrations for flight and wind tunnel are compared. Author

A88-40733#
DETERMINATION OF THE AERODYNAMIC CHARACTERISTICS OF THE MISSION ADAPTIVE WING
STEPHEN B. SMITH (USAF, Flight Test Center, Edwards AFB, CA) and DAVID W. NELSON (Boeing Co., Seattle, WA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 293-303. refs
(AIAA PAPER 88-2556)

The Advanced Fighter Technology Integration AFTI/F-111 program is an on-going joint Air Force/NASA/Boeing research program designed to develop and demonstrate the potential technology enhancements of the Mission Adaptive Wing (MAW). The primary features of the MAW are smooth contour, variable camber leading and trailing edge surfaces which can modify wing contour in flight by means of an internal linkage system, and flexible skins. Extensive wind tunnel and flight test data were gathered during the course of the program to define the aerodynamic performance benefits attributed to the MAW. Full scale aerodynamic characteristics and predicted performance were initially based on a 1/12 scale model wind tunnel data base and a theoretical FLEXSTAB model used to adjust the data. Flight testing was conducted to determine lift, drag, buffet and wing upper and lower surface pressures. The flight test data served to verify the wind tunnel predictions and to provide a data base for follow-on analyses. Author

A88-40734*# Stanford Univ., Calif.
NAVIER STOKES COMPUTATION OF THE FLOW FIELD OVER DELTA WINGS WITH SPANWISE LEADING EDGE BLOWING
DAVID T. YEH, DOMINGO A. TAVELLA, LEONARD ROBERTS (Stanford University, CA), and KOZO FUJII (National Aerospace Laboratory, Chofu, Japan) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 304-311. refs
(Contract NCC2-341)
(AIAA PAPER 88-2558)

The concept of spanwise leading edge blowing, a means of controlling the position and strength of leading edge vortices, is analyzed by numerical solutions of the three-dimensional Thin-Layer Navier Stokes equations. The leading edge jet is simulated by defining a permeable boundary, corresponding to the jet slot, where suitable boundary conditions are implemented. Numerical results agree favorably with experimental measurements. It is found that the use of spanwise leading edge blowing not only magnifies the size and strength of the leading edge vortices, but also moves the vortex cores outboard and upward. As a result, the increase in lift comes primarily from the greater nonlinear vortex lift. The presence of the leading edge jet stream displaces the flow outboard, thereby increasing the effective aspect ratio of the delta wing. However, blowing causes earlier vortex breakdown, thus decreasing the stall angle. Author

A88-40735*# Notre Dame Univ., Ind.
LEADING EDGE VORTEX DYNAMICS ON A PITCHING DELTA WING

S. P. LEMAY, S. M. BATILL, and R. C. NELSON (Notre Dame, University, IN) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 312-320. Research supported by the University of Notre Dame. refs
(Contract NAG1-727)
(AIAA PAPER 88-2559)

A study of the dynamic behavior of the leading edge vortices on a delta wing undergoing oscillatory pitching motion is presented. A sharp edge, flat plate, delta wing having a sweep angle of 70 deg was used in this investigation. The wing was sinusoidally pitched about its 1/2 chord position at reduced frequencies ranging from k = 2(pi)fc/u = 0.05 to 0.30 at chord Reynolds numbers between 90,000 and 350,000, for angle of attack ranges of 29 to 39 deg and 0 to 45 deg. During these dynamic motions, visualization of the leading edge vortices was obtained by marking the vortices with TiCl4 introduced through ports located near the model apex. The location of vortex breakdown was recorded using high speed motion picture photography. The motion picture records were analyzed to determine vortex trajectory and breakdown position as a function of angle of attack. When the wing was sinusoidally pitched, a hysteresis was observed in the location of breakdown position. This hysteresis increased with reduced frequency. The velocity of breakdown propagation along the wing, and the phase lag between model motion and breakdown location were also determined. Detailed information was also obtained on the oscillation of breakdown position in both static and dynamic cases. Author

A88-40736#
A METHOD TO INCREASE THE ACCURACY OF VORTICAL FLOW SIMULATIONS

KOZO FUJII (Tokyo, University, Kanagawa, Japan) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 321-328. refs
(AIAA PAPER 88-2562)

Even with recent supercomputers having a large memory, Navier-Stokes simulations for vortical flows do not provide satisfactory results because of the lack of grid resolution to accurately simulate strength of separation vortices. To overcome this problem, a zonal method is newly developed to increase the number of the grid points locally. Interface scheme which is critical for an efficient zonal method is based on the Fortified Navier-Stokes approach. Application to both two-dimensional conical and three-dimensional delta wing problems indicates this simple zonal method can improve the accuracy of vortical flow simulations. Author

A88-40737#
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE VORTEX FLOW OVER A YAWED DELTA WING

NICK G. VERHAAGEN and STEVE H. J. NAARDING (Delft, Technische Hogeschool, Netherlands) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 329-339. refs
(AIAA PAPER 88-2563)

The influence of yaw on the flow about a sharp-edged biconvex delta wing of a unit aspect ratio is investigated using flow visualization techniques, as well as pressure and force balance measurements. The tests have been carried at a constant incidence of 21.1 deg and at angles of sideslip ranging from zero to 20 deg. The free stream velocity was 44 m/sec, corresponding to a Reynolds number of 2.5 million, based on root chord. Up to 12 deg sideslip, the asymmetry of the vortex crossflow and surface pressure distribution depends on the increasing asymmetry in the strength and position of the vortices, as well as on boundary layer transition. At larger angles of sideslip the vortex flow and pressure distribution is in addition influenced by asymmetric bursting. The flow about the yawed wing is computed using a slender-body free-vortex-sheet method. Good agreement is obtained with experimental data on the part of the wing away from the apex and trailing edge. Author

A88-40738#
PNS CALCULATIONS OF HYPERSONIC TRANSITIONAL FLOW OVER CONES

T. BLUM and H. YOSHIHARA (Boeing Co., Seattle, WA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 340-346. refs
(AIAA PAPER 88-2565)

The McDonald/Fish (1972) equation was incorporated into the Parabolic Navier-Stokes method. The resulting approach yielded computations of hypersonic transitional flows over cones that agreed well with experiment. Specifically, the flow over two cones of 10 and 6 deg (half-angle) were computed at freestream Mach numbers of 6 and 13.27 respectively. The Stanton number curve for the 10 deg cone matched well with experiment and earlier boundary layer computations. The transition and turbulent segments of the 10 deg case agreed well with experiment while a laminar mismatch was observed. For completeness, skin friction curves and the precursor and overshoot effects are given although corresponding experimental data are not available. Author

A88-40739*# Dynamic Engineering, Inc., Newport News, Va.
COMPUTATIONAL VALIDATION OF A PARABOLIZED NAVIER-STOKES SOLVER ON A SHARP-NOSE CONE AT HYPERSONIC SPEEDS

LAWRENCE D. HUEBNER (Dynamic Engineering, Inc., Newport News, VA), JAMES L. PITTMAN (NASA, Langley Research Center, Hampton, VA), and ARTHUR D. DILLEY (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 347-356. refs
(AIAA PAPER 88-2566)

Perfect gas computational results from a newly-developed upwind, parabolized Navier-Stokes (PNS) solver are compared with an existing set of experimental laminar results for a 10-deg half-angle circular cone at freestream Mach number of 7.95. Comparisons were performed with surface pressure and heat transfer data, as well as with flowfield pitot measurements. The PNS code predicted the surface quantities accurately up through 20-deg angle-of-attack, including crossflow separation, and correctly defined the location of the bow shock and the edge of the boundary layer. The importance of cell Reynolds number, grid density, and thermal boundary conditions to the accurate prediction of the flowfield are examined through numerical emamples. Author

A88-40741#
VISUALIZATION AND ANEMOMETRY ANALYSES OF FORCED UNSTEADY FLOWS ABOUT AN X-29 MODEL

J. ASHWORTH, T. MOUCH, and M. LUTTGES (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 378-388. USAF-supported research. refs
(AIAA PAPER 88-2570)

The applicability of forced unsteady flow-induced lift enhancement technology is demonstrated by an investigation comparing flow visualization and hot wire velocity measurements of the flow about an X-29 wind tunnel model. Intricate interactions are noted between wingtip and leading edge vortices on the surface of the canard; these structures convect downstream, and influence the flow patterns of the swept-forward wings. Several hypotheses formulated during visualization studies are supported by hot wire velocity measurements taken above and below the surface of the wing. O.C.

A88-40742#
EXPERIMENTAL AND NUMERICAL STUDY OF THE PROPELLER/FIXED WING INTERACTION
D. FAVIER, C. MARESCA, C. BARBI (Aix-Marseille II, Universite, Marseille, France), and G. FRATELLO IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 389-398. refs
(Contract DRET-85-115)
(AIAA PAPER 88-2571)
Due to the recent development of high efficiency propeller airplanes, it has become necessary to better understand the effect of the slipstream on the nearby aircraft components. The slipstream influence has been investigated in a series of wind tunnel tests on propeller/nacelle/wing at subsonic speed. The experimental investigation was pursued so that the respective influence effect of each element has been deduced: propeller slipstream mean effects on the wing aerodynamic behavior as well as the modification induced by the wing on the propeller thrust and torque coefficients. The total aerodynamic loads as well as pressure distribution on the wing has been measured. A comparison is made with numerical pressure coefficient results obtained by modeling a wing immersed in the propeller slipstream calculated via a lifting line method. Author

A88-40743#
NUMERICAL ANALYSIS OF MULTIPLE ELEMENT HIGH LIFT DEVICES BY NAVIER STOKES EQUATION USING IMPLICIT TVD FINITE VOLUME METHOD
EIJI SHIMA (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 399-406. refs
(AIAA PAPER 88-2574)
This paper deals with the analysis of multiple element high lift devices by solving the Navier-Stokes equations using the TVD (Total Variation Diminishing) finite difference method. In order to generate a computational grid around the multiple element airfoils automatically, the grid generator using the elliptic method, in which Poisson equations are by the finite difference method, combined with 2-D panel method is developed. As to the flow solver, some improvements are added to the TVD scheme to calculate low Mach number flows efficiently. Numerical calculations are carried out for the single slotted flap configuration. Author

A88-40744#
NUMERICAL PREDICTION OF AERODYNAMIC PERFORMANCE FOR A LOW REYNOLDS NUMBER AIRFOIL
FEI-BIN HSIAO (National Cheng Kung University, Tainan, Republic of China) and CHENG-CHIANG HSU IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 407-413. refs
(AIAA PAPER 88-2575)
A simple scheme is developed for predicting the aerodynamic parameters and the bubble formation of a NACA 63(3)-018 symmetric airfoil at Reynolds number 300,000, based on the chord. The modified potential flow solutions associated with the vortex wake model are obtained numerically to study the wake effect on the airfoil performance when the flow is separated on the surface. A reasonable agreement is made between the prediction and the experiment in the computed range of angles of attack. The CPU time for this scheme is very little when compared to some computational solvers. Author

A88-40745*# Ohio State Univ., Columbus.
EXPERIMENTAL MEASUREMENTS ON AN OSCILLATING 70-DEGREE DELTA WING IN SUBSONIC FLOW
M. R. SOLTANI, M. B. BRAGG (Ohio State University, Columbus), and J. M. BRANDON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 414-427. refs
(AIAA PAPER 88-2576)
A series of low-speed wind tunnel tests on a 70-degree sharp leading-edged delta wing at both static and dynamic conditions were performed to investigate the aerodynamic forces and moments. Forces and moments were obtained from a six component internal strain gauge balance. Static results compared well with the previous experimental findings. Large amplitude dynamic motion was produced by sinusoidally oscillating the model over a range of reduced frequencies. Substantial force and moment overshoots, a delay in dynamic stall, and hysteresis loops between the values of aerodynamnic loads in upstroke and downstroke motion were observed, all of which were strong functions of the reduced frequency. The aerodynamic forces and moments were influenced by the Reynolds number. Asymmetrical vortex bursting produced by nonzero sideslip angle created a complex rolling moment variations with angle of attack. Author

A88-40746#
PITCH RATE AND REYNOLDS NUMBER EFFECTS ON A PITCHING RECTANGULAR WING
MICHAEL C. ROBINSON (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) and JOHN B. WISSLER (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 428-440. USAF-sponsored research. refs
(AIAA PAPER 88-2577)
Unsteady pressure measurements were collected from a pitching NACA 0015 wing at several span locations. The transient pressure signatures indicated the formation of both a leading edge and wingtip vortex as the wing pitched from 0 to 60 deg. Inboard, away from the wingtip, the dynamic stall vortex initiation and convection appeared two-dimensional. Near the wingtip, strong orthogonal vortex-vortex interactions prolonged vortex residence times and enhanced the sectional lift coefficients. These transient enhancements were directly dependent upon pitch rate. Reynolds number effects on vortex development were minor over the limited range tested. Author

A88-40747*# Mississippi State Univ., Mississippi State.
THREE-DIMENSIONAL UNSTEADY TRANSONIC VISCOUS-INVISCID INTERACTION USING THE EULER AND BOUNDARY-LAYER EQUATIONS
DAVID L. WHITFIELD (Mississippi State University, Mississippi State) and SHAHYAR PIRZADEH IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 441-453. refs
(Contract NAG1-226)
(AIAA PAPER 88-2578)
The objective of this study is the development of a numerical technique which can provide three-dimensional, time-accurate, compressible, turbulent flow solutions in a practical and relatively economical way. The approach taken is that of the method of viscous-inviscid interaction. The Euler equations are assumed to govern the outer inviscid portion of the flow, and the viscous layer close to the solid wall is described by a set of integral boundary-layer equations. The viscous solutions are obtained in a direct fashion with a weighted-average phase error scheme. The method of equivalent sources is used for viscous-inviscid coupling. Steady-state and unsteady computations for an AGARD airfoil and a wing show that satisfactory engineering solutions can be obtained for attached, high Reynolds number flows using this method. Quasi-unsteady interactions are shown to produce similar results to those provided by true-unsteady interactions. Considerable computer resources can be saved for some cases by using quasi-unsteady interactions. Author

A88-40748#

UNSTEADY AERODYNAMIC FORCES AT LOW AIRFOIL PITCHING RATES

JULIE A. ALBERTSON, TIMOTHY R. TROUTT (Washington State University, Pullman), and CHRISTOPHER R. KEDZIE (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 454-462. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 88-2579)

Experiments were conducted on a NACA-0015 airfoil undergoing low constant pitch rates to study the effects of dynamic stall formation on the airfoil upper surface pressure field. The airfoil was pitched about pivot locations of 0.25c, 0.50c, and 0.75c at nondimensional pitch rates below 0.2. Lift and drag coefficients were evaluated for all cases, and smoke flow visualization at low pitch rates was studied for the quarter chord pivot location. Results indicate that the greatest increases in lift due to the pitching motion occur prior to the nondimensional pitch rate of 0.1 for all three pivot locations. The effects of pitch rate on the maximum lift and drag values appear similar for the three pivot locations studied. Lift to drag ratios show significant enhancement even at very low nondimensional pitch rates. Flow visualization indicates that the leading-edge dynamic stall vortex is present even at very low nondimensional pitch rates. Author

A88-40749#

IMPINGEMENT OF ORTHOGONAL UNSTEADY VORTEX STRUCTURES ON TRAILING AERODYNAMIC SURFACES

JOHN M. WALKER and MICHAEL C. ROBINSON (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 463-472. USAF-supported research. refs
(AIAA PAPER 88-2580)

Wind tunnel experiments were conducted with a generic wing-canard type configuration which consisted of two 6-in. NACA 0015 sections placed in tandem one chord length apart. The 1.8c semispan canard was pitched from 0 to 60 deg angle-of-attack at constant nondimensional rates ranging from 0.05 to 0.2 about its quarter-chord axis. These motions produced energetic three-dimensional dynamic stall and wing tip vortex flows which impinged on the 2.5c semispan trailing wing set at a geometric angle of incidence of zero deg. Smoke-wire flow visualization and dynamic surface pressure measurements were performed to study the effects of the unsteady vortical wakes on the trailing wing. These unsteady vortex structures produced by the pitching canard elicited complex, time dependent secondary flows about the trailing wing which in turn produced large dynamic loads. Author

A88-40750#

UNSTEADY FLOW INTERACTIONS BETWEEN THE WAKE OF AN OSCILLATING AIRFOIL AND A STATIONARY TRAILING AIRFOIL

STEPHEN A. HUYER and MARVIN W. LUTTGES (Colorado, University, Boulder) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 473-482. refs
(Contract F49620-83-K-0009)
(AIAA PAPER 88-2581)

The flow field interaction between the unsteady wake generated by an oscillating upstream airfoil and stationary trailing airfoil was examined in detail for high trailing airfoil angles of attack. Mean angle and oscillation amplitude of the upstream airfoil were held constant across sinusoidally pitching at two reduced frequencies. The angle of attack of the trailing airfoil was then varied to angles exceeding stall in order to evaluate the possibility of dynamically re-attaching flow. Flow interactions were recorded and measured using multiple exposure, phase locked flow visualization photographs and surface pressure measurements. The upstream airfoil produced a dynamic stall-trailing edge tandem vortex pair followed by a separated wake region. These unsteady flow fields then interacted with the trailing airfoil producing highly transient aerodynamic loading evidenced by the measured pressure distribution. Both lift enhancement and thrusting effects were produced on the trailing airfoil under certain test conditions. Since the flow fields produced significant complexities in terms of control, additional studies need to be conducted to identify possible methods of enhancing positive and avoiding adverse flow interactions occurring between active and passive tandem lifting surfaces. Author

A88-40751#

A COMPARATIVE STUDY OF DIFFERING VORTEX STRUCTURES ARISING IN UNSTEADY SEPARATED FLOWS

STEPHEN A. HUYER, MARK A. REAVIS, and MARVIN W. LUTTGES (Colorado, University, Boulder) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 483-491. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 88-2582)

The vortex structures arising in two different unsteady separated flow tests were examined in detail. Flow fields resulting from the deployment of a periodically deforming leading edge (PDLE) and an oscillating flat plate were studied and compared. The PDLE produced two separate vortex structures during each complete deformation cycle. It was found through flow visualization and hot-wire anemometry that these two structures exhibited quite different characteristics. The primary vortex, initiated at approximately maximum PDLE deployment, was characterized by low, constant velocities within the vortex. The measured velocities increased threefold, to 120 percent freestream values, across a hot-wire displacement of 3 mm. The second vortex, initiated at approximately minimum PDLE deployment, exhibited a more evenly graded vortex rotation rate with no evidence of spatially-dependent stepwise changes in velocity. The vortex structures produced by an oscillating flat plate were also examined. It was found that a reduced frequency of 3 yielded a more cohesive vortex compared to that produced by a reduced frequency of 1. The structures produced by PDLE deployment were also considerably weaker than those produced by an oscillating flat plate. Author

A88-40752*# Sterling Software, Palo Alto, Calif.

AN UPWIND DIFFERENCING SCHEME FOR THE TIME-ACCURATE INCOMPRESSIBLE NAVIER-STOKES EQUATIONS

STUART E. ROGERS (Sterling Software, Palo Alto, CA) and DOCHAN KWAK (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 492-502. refs
(AIAA PAPER 88-2583)

The two-dimensional incompressible Navier-Stokes equations are solved in a time-accurate manner in using the method of pseudocompressibility. Using this method, subiterations in pseudotime are required to satisfy the continuity equation at each time step. An upwind differencing scheme based on flux-difference splitting is used to compute the convective terms. The upwind differencing is biased based on the sign of the local eigenvalue of the Jacobian matrix. Third-order or fifth-order spatial accuracy is maintained throughout the interior grid points. The equations are solved using an implicit line-relaxation scheme. This solution scheme is stable and is capable of running at large time steps in pseudotime, leading to fast convergence for each physical time step. A variety of computed results are presented to validate the present scheme. Results for the flow over an oscillating plate are compared with the exact analytic solution, good agreement is seen. Excellent comparison is obtained between the computed solution and the analytical results for inviscid channel flow with an oscillating back pressure. Flow solutions over a circular cylinder with vortex shedding are also presented. Finally, the flow past an airfoil at -90 deg angle-of-attack is also computed. Author

A88-40755#

APPLICATION OF NAVIER-STOKES ANALYSIS TO PREDICT THE INTERNAL PERFORMANCE OF THRUST VECTORING TWO-DIMENSIONAL CONVERGENT-DIVERGENT NOZZLES

G. J. SOVA (Rockwell International Corp., Los Angeles, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 522-527. Research supported by the Rockwell International Independent Research and Development Program. refs

(AIAA PAPER 88-2586)

Rockwell's two-dimensional Navier-Stokes solver has been used to predict the internal performance of a thrust vectoring two-dimensional nozzle operating at pressure ratios of 5.04 (unseparated) and 3.03 (separated). Turbulent flow is assumed and the Baldwin-Lomax eddy viscosity formulation is used in the Reynolds-averaged form of the Navier-Stokes equations. Comparisons with test data are quite favorable. It is anticipated that routine analysis of generic nozzles can be realized in a timely (less than one man week of effort) and cost effective manner. Author

A88-40756*# PEDA Corp., Palo Alto, Calif.

CSCM NAVIER-STOKES THERMAL/AERODYNAMIC ANALYSIS OF HYPERSONIC NOZZLE FLOWS WITH SLOT INJECTION AND WALL COOLING

WILLIAM H. CODDING, C. K. LOMBARD, and J. Y. YANG (PEDA Corp., Palo Alto, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 528-542. refs

(Contract NAS2-12243; NASA ORDER A-56829-C)

(AIAA PAPER 88-2587)

The Conservative Supra-Characteristic Method (CSCM) Navier-Stokes solver is applied to ascertain the problems inherent in the design of a nominal Mach 14 nozzle for NASA-Ames' 3.5-ft Hypersonic Wind Tunnel; attention is given to the effects of boundary layer cooling systems on the aerodynamic redesign of the nozzle throat region. Complete nozzle flowfields are calculated with and without slot injection of either hot or cold fluid into the boundary layer just upstream of the throat, as well as with alternatively adiabatic and cold walls. The CSCM method is capable of resolving subtle differences in the flows. O.C.

A88-40757*# North Carolina State Univ., Raleigh.

UNSTEADY VISCOUS-INVISCID INTERACTION PROCEDURES FOR TRANSONIC AIRFOILS USING CARTESIAN GRIDS

CHARLES C. FENNO, JR., H. A. HASSAN (North Carolina State University, Raleigh), and PERRY A. NEWMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 543-551. refs

(Contract NGT-34-002-801; NAGW-1072)

(AIAA PAPER 88-2591)

A viscous-inviscid interaction procedure for transonic airfoils using an Euler/integral boundary layer formulation and Cartesian grids is presented. The approach is based on a time dependent formulation for both the integral boundary layer equations and the Euler equations. Effects of upstream history on the shear stress are modeled by a time dependent rate equation derived from the turbulent kinetic energy equation. Results are presented for two of the test cases reported by Cook et al. (1979) for the RAE 2822 supercritical airfoil and one of the cases reported by Harris (1981) for the NACA 0012 symmetric airfoil. In general, the results are in good agreement with experiment. Author

A88-40758#

TURBULENT EDDY VISCOSITY MODELING IN TRANSONIC SHOCK/BOUNDARY LAYER INTERACTIONS

G. R. INGER (Iowa State University of Science and Technology, Ames) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 552-560. refs

(AIAA PAPER 88-2592)

The treatment of turbulence effects on transonic shock/turbulent boundary layer interaction is addressed within the context of a triple deck approach valid for arbitrary practical Reynolds numbers between 1000 and 10 billion. The modeling of the eddy viscosity and basic turbulent boundary profile effects in each deck is examined in detail using Law-of-the-Wall/Law-of-the-Wake concepts as the foundation. Results of parametric studies showing how each of these turbulence model aspects influences typical interaction zone property distributions (wall pressure, displacement thickness and local skin friction) are presented and discussed. Author

A88-40760#

NONINTRUSIVE MEASUREMENTS OF VORTEX FLOWS ON DELTA WINGS IN A WATER TUNNEL

STEVEN L. MORRIS, DONALD T. WARD (Texas A & M University, College Station), GERALD N. MALCOLM, and LIANE C. LEWIS (Eidetics International, Torrance, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 568-581. refs

(Contract F49620-87-C-0069)

(AIAA PAPER 88-2595)

The 'ExpertVision' nonintrusive videoimaging system has been used as the basis of a novel method for quantifying vortex flow field data in a water tunnel, so that the location and movement of the vortex core can be ascertained through the systematic tracking of colored dye jets ejected from models into the surrounding flow field. Automated data-reduction software then calculated position, velocity, and acceleration from the trace of specified images in the digitized video field-of-view. Vortex core burst point dynamics were also quantified. Forced oscillation measurements furnished phase correlations between model motion and vortex core velocities, as well as between model motion and vortex-burst point location. O.C.

A88-40761#

THE EFFECT OF CROSS FLOW ANGLE ON THE DRAG AND LIFT COEFFICIENTS OF NON-CIRCULAR CYLINDER WITH STRAKES

BANDU N. PAMADI (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 582-592. refs

(AIAA PAPER 88-2599)

In a recent study, the installation of a pair of thin strakes on the windward face of a noncircular cylinder in subcritical flow was found to give substantial drag reduction. The primary fluid flow mechanism which gave optimum drag reduction up to 81.5 percent was identified as the smooth, tangential, turbulent reattachment of the flow separating from the strakes at the corners. In this paper, the effect of cross flow incidence on this flow mechanism is investigated. Also, the drag and lift forces of the body are presented for cross flow angles up to + or - 90 deg. Author

A88-40762*# Old Dominion Univ., Norfolk, Va.

CALCULATIONS OF THREE-DIMENSIONAL FLOWS USING THE ISENTHALPIC EULER EQUATIONS WITH IMPLICIT FLUX-VECTOR SPLITTING

FRANK E. CANNIZZARO, E. VON LAVANTE (Old Dominion University, Norfolk, VA), and N. DUANE MELSON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 593-614. refs

(Contract NAG1-633)
(AIAA PAPER 88-2516)

A numerical method for solving the isenthalpic form of the Euler equations is developed. The method is based on the concept of flux vector splitting in its implicit form applied to a cell centered finite volume scheme. Approximate factorization is implemented in solving the implicit part of the governing equations. Time marching to a steady state solution requires short computational times due to the relative efficiency of the basic method. Computational times are further reduced by the implementation of multigrid. Results for several basic cases are shown. Author

A88-40763*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

FLIGHT TESTS OF EXTERNAL MODIFICATIONS USED TO REDUCE BLUNT BASE DRAG

SHERYLL GOECKE POWERS (NASA, Flight Research Center, Edwards, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 615-628. Previously announced in STAR as N88-20279. refs
(AIAA PAPER 88-2553)

The effectiveness of a trailing disk (the trapped vortex concept) in reducing the blunt base drag of an 8-in diameter body of revolution was studied from measurements made both in flight and in full-scale wind-tunnel tests. The experiment demonstrated the significant base drag reduction capability of the trailing disk to Mach 0.93. The maximum base drag reduction obtained from a cavity tested on the flight body of revolution was not significant. The effectiveness of a splitter plate and a vented-wall cavity in reducing the base drag of a quasi-two-dimensional fuselage closure was studied from base pressure measurements made in flight. The fuselage closure was between the two engines of the F-111 airplane; therefore, the base pressures were in the presence of jet engine exhaust. For Mach numbers from 1.10 to 1.51, significant base drag reduction was provided by the vented-wall cavity configuration. The splitter plate was not considered effective in reducing base drag at any Mach number tested. Author

A88-40764*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RIBLET DRAG REDUCTION AT FLIGHT CONDITIONS

MICHAEL J. WALSH, WILLIAM L. SELLERS, III, and CATHERINE B. MCGINLEY (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 629-638. refs
(AIAA PAPER 88-2554)

Paper describes perforated and nonperforated riblet tests on the fuselage of a modified Learjet Model 28/29 twin-engine business jet at Reynolds numbers 1.0-2.75 x 10 to the 6th/ft and Mach numbers 0.3-0.7. Drag reductions of the order of 6 percent at nondimensional wall spacings of 12 were obtained using boundary-layer rakes and direct drag balances. At the measurement locations the Reynolds number based on distance was 1.0-46 x 10 to the 6th. The nondimensional wall spacing for maximum drag reduction was well-predicted by low-speed wind-tunnel data, but the maximum drag reduction was lower. The low drag is tentatively ascribed to various instrumentation difficulties and the flow field on the aircraft. Riblets with 0.010-in. perforations at center spacings of 0.25 in. were found to give the same drag reduction as nonperforated riblets. Author

A88-40765*# Analytical Services and Materials, Inc., Hampton, Va.

DESIGN OF LOW REYNOLDS NUMBER AIRFOILS. I

W. PFENNINGER and C. S. VEMURU (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 639-655. refs
(Contract NAS1-18235)
(AIAA PAPER 88-2572)

The low Reynolds number airfoils designated ASM-LRN-003 and -007 have been designed for high section L/D ratios using Drela's (1985) design-and-analysis code; close to 70-percent laminar flow is maintained on the upper surfaces, and 100-percent on the lower, at coefficients of lift of 1.0-1.3, assuming optimum laminar separation and transition control on the upper surface by means of suitable turbulators. If peak performance is critical, airfoils of this type with an undercut front lower surface and a correspondingly sharper leading edge may be resorted to. O.C.

A88-40766*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIMENTAL AND THEORETICAL STUDY OF THE EFFECTS OF WING GEOMETRY ON A SUPERSONIC MULTIBODY CONFIGURATION

STEVEN X. S. BAUER and S. NAOMI MCMILLIN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 656-664. refs
(AIAA PAPER 88-2510)

An experimental and theoretical investigation of planform effects on a low-fineness ratio multibody configuration was conducted in NASA-Langley Research Center's Unitary Plan Wind Tunnel at Mach number of 1.6, 1.8, 2.0 and 2.16. Experimental and theoretical values of lift, drag, and pitching moment as well as surface pressures were obtained on several configurations which varied in both outboard-wing panel and inboard-wing panel planforms. The three outboard-wing panels were a 65 -deg delta and two trapezoidal wing planforms. An unswept and a 60-deg swept inboard-wing panels were also tested. The purpose of the study was to determine the effect of wing planform on the supersonic aerodynamics. The large trapezoidal wing provided increased performance over the small trapezoidal wing primarily due to a reduction in the zero-lift drag coefficient. The swept inboard-wing panel planforms provided a slightly higher L/D than the unswept inboard-wing panel due to a minimal improvement in zero-lift drag. Linear-theory aerodynamic codes were used to analyze the effect of planform on the supersonic aerodynamics and were found to generally produce adequate results. Author

A88-40767*# Vigyan Research Associates, Inc., Hampton, Va.

NAVIER-STOKES COMPUTATION OF FLOW AROUND A ROUND-EDGED DOUBLE-DELTA WING

C.-H. HSU (Vigyan Research Associates, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 665-673. refs
(AIAA PAPER 88-2560)

Computations of three-dimensional vortical flows over a thin round-edged double-delta wing with an aspect ratio of 2.05 are performed using an implicit upwind-relaxation finite-difference scheme. The effects of grid and angle of attack on the Navier-Stokes computations are studied. Coarse-grid calculations can not predict the detailed structures of the vortical flowfields for lack of grid resolution. On the contrary, fine-grid computations show that key features of vortex formation, interaction, and breakdown are simulated. Furthermore, computed lift coefficients and spanswise surface static pressure distributions are in good agreement with the experimental data up to alpha = 25 deg. Author

A88-40768#

FURTHER ANALYSIS OF WING ROCK GENERATED BY FOREBODY VORTICES

L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 674-686. refs
(AIAA PAPER 88-2597)

More intensive analytical efforts for the wing rock that can be generated by forebody vortices have uncovered numerous flow phenomena capable of giving rise to the wing rock observed experimentally; comparatively small aircraft geometry changes result in the rise to dominant status of very different flow mechanisms, thereby affecting the nature of wing rock. Wing rock generated by slender forebody vortices is not only far more severe than slender wing rock due to asymmetric leading edge vortices, but is also that which is most prevalent in current and projected advanced aircraft types. O.C.

A88-40771#

COMPUTATIONAL SIMULATION OF VORTEX GENERATOR EFFECTS ON TRANSONIC SHOCK/BOUNDARY LAYER INTERACTION

G. R. INGER (Iowa State University of Science and Technology, Ames) and TIMOTHY SIEBERSMA AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 8 p. refs
(AIAA PAPER 88-2590)

The influence of shock/boundary layer interaction on a supercritical wing can extend significantly downstream within the boundary layer, and thus adversely affect global aerodynamic properties. This negative influence may be reduced with the appropriate application of boundary layer control. One method of boundary layer control, the vortex generator, has been shown to be effective in delaying separation by promoting mixing between the free stream and the boundary layer. In this study, we seek to simulate the effects of a vortex generator located ahead of the shock/boundary layer interaction zone on a supercritical wing. The vortex generator is represented by parameters characterizing the Law of the Wall/Law of the Wake structure of the turbulent boundary layer. This vortex generator model is integrated into a previously-developed computational model of a shock/boundary layer interaction that utilizes an appropriate triple deck theory of the interaction. The results of a parametric study of this simulated vortex generator effect on the interaction zone flow are then presented. Author

A88-40970

UNSTEADY NONSIMILAR LAMINAR COMPRESSIBLE BOUNDARY-LAYER FLOW OVER A YAWED INFINITE CIRCULAR CYLINDER

R. VASANTHA and G. NATH (Indian Institute of Science, Bangalore, India) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 39, no. 1-2, 1987, p. 13-26. refs

Unsteady nonsimilar laminar compressible boundary-layer flow over a yawed infinite circular cylinder has been studied when the external flow is nonhomentropic and varies arbitrarily with time. The governing partial differential equations have been solved numerically using an implicit finite-difference scheme with quasi-linearization technique. The results have been obtained for both an accelerating stream and fluctuating stream. The skin-friction and heat-transfer parameters respond significantly to the unsteadiness in the external flow field. It is observed that, in the case of nonhomentropic flow, the heat-transfer parameter increases along the streamwise coordinate up to some x and then decreases. The effects of the yaw angle and Mach number are found to be more pronounced for the unsteady case than for the steady case. Increase in wall temperature, Mach number and time cause the point of zero skin friction to shift upstream. Author

A88-40972

DEVELOPMENT OF AN AIRFOIL OF HIGH LIFT/DRAG RATIO AND LOW MOMENT COEFFICIENT FOR SUBSONIC FLOW

W. KANIA and M. ANTOSIEWICZ (Instytut Lotnictwa, Warsaw, Poland) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 39, no. 1-2, 1987, p. 63-72. refs

A NUMERICAL method is used to design a new airfoil of high lift/drag ratio and moment coefficient close to zero at the specified subsonic flow condition. Attainment of the desired aerodynamic properties of this airfoil is verified by performing special experimental studies in the trisonic wind tunnel. The aerodynamic characteristics of the designed airfoil are compared with several advanced and conventional airfoils. Author

A88-41048#

ON INVERSE AIRFOIL DESIGN

PRABIR DARIPA (Texas A & M University, College Station) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 10 p. refs
(AIAA PAPER 88-2573)

We discuss mostly the theoretical aspects of our approach to inverse airfoil design. The methods we propose to solve the inverse airfoil problem for subcritical and supercritical flows are based on the formulation of the problem in the potential plane. Some of our methods have been used to generate subcritical airfoils. Further numerical work for subsonic and transonic cases is in progress. Author

A88-41092#

A NUMERICAL STUDY OF VISCOUS FLOW IN INLETS AND AUGMENTORS

J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. refs
(AIAA PAPER 88-0187)

Flowfields through two-dimensional and axisymmetric inlets and thrust-augmenting ejectors are modeled by use of the thin-layer approximation to the unsteady Reynolds-averaged Navier-Stokes equations. The equations are solved by an explicit multistage Runge-Kutta time-stepping method employing a finite-volume formulation on body-conforming curvilinear grids. Eddy viscosity models are used to describe turbulence effects. Results compare well with experimental data for transonic inlet flows. Improvements in turbulence modeling are needed for better prediction of ejector flowfields. Author

A88-41269

ON THE USE OF SUBCYCLING FOR SOLVING THE COMPRESSIBLE NAVIER-STOKES EQUATIONS BY OPERATOR-SPLITTING AND FINITE ELEMENT METHODS

M. O. BRISTEAU, R. GLOWINSKI (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), B. MANTEL, J. PERIAUX (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France), and G. S. SINGH (Bhabha Atomic Research Centre, Bombay, India) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 4, May-June 1988, p. 309-317. refs
(Contract DRET-83-403)

In this paper, the solution of the compressible Navier-Stokes equations by numerical techniques combining finite element approximations, operator splitting for the time discretization, and numerical treatment of the nonlinearities by subcycling, is discussed. In this context this means that on the basic time discretization interval a time integration is performed by a standard numerical scheme for initial-value problems (explicit schemes in this paper). Numerical results for flows around a NACA 0012 aerofoil are presented. Author

A88-41270* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AN OVERVIEW OF HYPERSONIC AEROTHERMODYNAMICS

GARY T. CHAPMAN (NASA, Ames Research Center, Moffett Field, CA) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 4, May-June 1988, p. 319-325. refs

This paper briefly reviews some national studies and new programs concerning hypersonic flight. The flight environment that will be encountered by this new class of hypersonic vehicles is described, and the fluid-dynamic and chemical phenomena that occur in hypersonic flight are examined. Ground-based facilities are briefly described, and their use in helping to validate the codes is examined. C.D.

N88-22004# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.

CONTROL OF LAMINAR FLOW AROUND OF THE WING IN FREE-AIR CONDITIONS

V. B. ZOZULYA and O. R. CHERANOVSKIY 4 Dec. 1987 16

p Transl. into ENGLISH from Collection of Hydromechanics (USSR), issue 20, 1972 p 37
(AD-A187479; FTD-ID(RS)T-1042-87) Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of the initial turbulence of flow on the distribution of the speed of suction from the boundary layer of the penetrated plate with the ideally smooth surface is examined. However, it is known that the initial turbulence of the atmosphere is considerably less than the corrected values. As the investigations, carried out by Shaubauer and Skramstad showed, with the sufficienly low turbulence level (order 0.08 percent) there is so-called upper critical Reynolds number. Therefore, the experimental confirmation of this face under the conditions of free atmosphere is of interest, and also the explanation of the minimally necessary suction intensity under such conditions. The decrease of initial turbulence in comparison with the value of turbulence in the duct by an order must lead to the noticeable increase in the extent of laminar section, which, however, under the conditions of the atmosphere must be limited by the value of the upper critical Reynolds number. In connection with this the value of suction intensity, necessary for the laminar flow, can be lowered approximately doubly in comparison with the values of intensity, obtained in the duct when epsilon = 0.2 percent. Author

N88-22005# Naval Postgraduate School, Monterey, Calif.
HIGH REYNOLDS NUMBER, LOW MACH NUMBER, STEADY FLOW FIELD CALCULATIONS OVER A NACA 0012 AIRFOIL USING NAVIER-STOKES AND INTERACTIVE BOUNDARY LAYER THEORY M.S. Thesis
LISA J. COWLES Dec. 1987 118 p
(AD-A189871) Avail: NTIS HC A06/MF A01 CSCL 20D

A Navier-Stokes code, developed by N. L. Sankar, and an Interactive Boundary Layer code, developed by Tuncer Cebeci, are implemented for high Reynolds number, low Mach flows over a NACA 0012 airfoil. Upper surface pressure distribution, coefficients of lift, coefficients of friction, and velocity profiles obtained from the Navier-Stokes code are compared to results obtained from the Cebeci Interactive Boundary Layer code for steady flow. The steady state cases investigated are at .3 Mach and Reynolds numbers of 1 to 5 million and at .12 Mach and a Reynolds number of 1.5 million. GRA

N88-22006# Flow Research, Inc., Kent, Wash.
UNSTEADY AERODYNAMICS OF A WORTMANN FX-63-137 WING IN A FLUCTUATING WIND FIELD Final Report, 15 Sep. 1983 - 15 Sep. 1987
H.-T. LIU Nov. 1987 61 p
(Contract N00014-83-C-0694)
(AD-A190128; FLOW-RR-431) Avail: NTIS HC A04/MF A01 CSCL 01A

An environmental aerodynamic test (EATS) was designed and assembled to investigate the effects of gust and turbulence on the performance of a full-scale Wortmann FX-63-137 wing. Experiments were conducted in the atmospheric boundary layer by directing the elevated wing into the prevailing wind for a range of Reynolds numbers from 80,000 to 450,000. The unsteady wind field, in essence, introduces significant and favorable effects on the aerodynamics in terms of lift overshoot, stall delay, reduction of drag at small angles of attack, and endurance enhancement. Further analysis of the field data was conducted to investigate the unsteady aerodynamic phenomena, such as the hysteresis loops and the spectra of the aerodynamic forces and the relation to the ambient wind conditions. GRA

N88-22007# Arizona Univ., Tucson.
EXPERIMENTAL INVESTIGATION OF A SPANWISE FORCED MIXING LAYER Annual Report, 1 Jul. 1986 - 30 Jun. 1987
A. GLEZER, I. J. WYGNANSKI, and T. F. BALSA 7 Nov. 1987 39 p
(Contract AF-AFOSR-0324-86)
(AD-A190136; AFOSR-87-1903TR) Avail: NTIS HC A03/MF A01 CSCL 20D

The occurrence of three-dimensional motion within a plane mixing layer results in a significant increase of the internal mixedness (mixing transition). The three-dimensional motion necessary for mixing is induced by streamwise, counter-rotating vortex pairs superimposed on the primary spanwise vortices. While their appearance in the plane mixing layer has been established, their origin and their evolution with increasing streamwise distance remains an enigma. Stability considerations indicate that an instability in the spanwise direction may lead to the generation of streamwise vorticity. This suggests that the flow may be susceptible to low level spanwise periodic forcing. Previous experiments have demonstrated that forcing allows the enhancement of individual instability modes and is an essential step towards understanding the evolution of the natural flow. Furthermore, application of forcing to the flow provides a powerful tool of considerable practical significance for the control of the downstream evolution. We have begun an experimental investigation of a plane mixing layer which is forced independently in the spanwise and streamwise directions. Our objective is to study the evolution of spanwise instability. GRA

N88-22008# Douglas Aircraft Co., Inc., Long Beach, Calif.
OSCILLATING AIRFOILS: ACHIEVEMENTS AND CONJECTURES Final Report, Oct. 1986 - Sep. 1987
TUNCER CEBECI Sep. 1987 31 p
(Contract F49620-87-C-0004)
(AD-A190490; MDC-K0535; AFOSR-87-1779TR) Avail: NTIS HC A03/MF A01 CSCL 20D

Recent developments and applications of an interactive boundary layer procedure for unsteady flows are reviewed. The emphasis is on a model problem corresponding to an oscillating thin airfoil in laminar flows and results are reported for different amplitudes and frequencies of oscillation. The use of the characteristic box scheme, with its stability criterion, are shown to allow the accurate calculation of reverse flows and the interaction procedure removes the singularity to allow calculation through regions of separated flow. Although the current focus of the interactive boundary layer procedure has been on the leading edge region, it has general applicability and, together with models for transition and turbulent flows, it can provide the basis for a method to deal with oscillation airfoils and wings and the rapid movement of fixed wing arrangements at angles of attack up to and beyond those of dynamic stall. Calculations at high angles of attack show that the behavior of the unsteady separated leading edge flow has similarities to steady flows down-stream of surface corrugations. The use of linear stability theory in the latter case shows that the locations of the onset of transition moves upstream with severity of corrugation and can move inside the separation bubble. In practice this means that the bubbles will be shortened and analogy with unsteady flows suggests that transition may play an important role. GRA

N88-22009*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL FLUID DYNAMICS DRAG PREDICTION: RESULTS FROM THE VISCOUS TRANSONIC AIRFOIL WORKSHOP
TERRY L. HOLST Apr. 1988 15 p Workshop held Jan. 1987
(NASA-TM-100095; A-88142; NAS 1.15:100095) Avail: NTIS HC A03/MF A01 CSCL 01A

Results from the Viscous Transonic Airfoil Workshop are compared with each other and with experimental data. Test cases used include attached and separated transonic flows for the NACA 0012 airfoil. A total of 23 sets of numerical results from 15 different author groups are included. The numerical method used vary widely and include: 16 Navier-Stokes methods, 2 Euler boundary layer methods, and 5 potential boundary layer methods. The results indicate a high degree of sophistication among the numerical methods with generally good agreement between the various computed and experimental results for attached or moderately separated cases. The agreement for cases with larger separation is only fair and suggests additional work is required in this area. Author

N88-22010*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC NAVIER-STOKES COMPUTATIONS OF STRAKE-GENERATED VORTEX INTERACTIONS FOR A FIGHTER-LIKE CONFIGURATION
STEVE REZNICK Feb. 1988 117 p
(NASA-TM-100009; A-87288; NAS 1.15:100009) Avail: NTIS HC A06/MF A01 CSCL 01A

Transonic Euler/Navier-Stokes computations are accomplished for wing-body flow fields using a computer program called Transonic Navier-Stokes (TNS). The wing-body grids are generated using a program called ZONER, which subdivides a coarse grid about a fighter-like aircraft configuration into smaller zones, which are tailored to local grid requirements. These zones can be either finely clustered for capture of viscous effects, or coarsely clustered for inviscid portions of the flow field. Different equation sets may be solved in the different zone types. This modular approach also affords the opportunity to modify a local region of the grid without recomputing the global grid. This capability speeds up the design optimization process when quick modifications to the geometry definition are desired. The solution algorithm embodied in TNS is implicit, and is capable of capturing pressure gradients associated with shocks. The algebraic turbulence model employed has proven adequate for viscous interactions with moderate separation. Results confirm that the TNS program can successfully be used to simulate transonic viscous flows about complicated 3-D geometries.
Author

N88-22011*# University of Southern California, Los Angeles. Dept. of Aerospace Engineering.
PRESSURE MEASUREMENTS OF IMPINGING JET WITH ASYMMETRIC NOZZLE Progress Report
CHIH-MING HO May 1988 24 p
(Contract NAG1-819)
(NASA-CR-182759; NAS 1.26:182759) Avail: NTIS HC A03/MF A01 CSCL 01A

For modern aircraft, impinging surfaces are commonly used as a device for obtaining vector thrust from engine exhaust. The nature of dynamic loading is important to understand for design purposes. In this study, the frequency, mode, and level of pressure fluctuations generated by an elliptic jet are examined. The elliptic jet is used because it has several operational advantages over a circular jet.
Author

N88-22012*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LASER VELOCIMETER MEASUREMENTS IN A WING-FUSELAGE TYPE JUNCTURE
J. SCHEIMAN and L. R. KUBENDRAN (Analytical Services and Materials, Inc., Hampton, Va.) Apr. 1988 9 p Presented at the IEEE 11th International Congress on Instrumentation in Aerospace Simulation Facilities, Stanford, Calif., 26-28 Aug. 1985
(NASA-TM-100588; NAS 1.15:100588) Avail: NTIS HC A02/MF A01 CSCL 01A

A single axis, five beam, three component laser velocimeter system was used in a juncture flow experiment. A description of the seeding system developed for and used in this experiment is given. The performanace of the LV system was evaluated, and some of the problems associated with it were identified. Satisfactory results were obtained in the juncture flow experiments using this LV system.
Author

N88-22013*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BOUNDARY-LAYER AND WAKE MEASUREMENTS ON A SWEPT, CIRCULATION-CONTROL WING
FRANK W. SPAID (McDonnell-Douglas Research Labs., St. Louis, Mo.) and EARL R. KEENER Dec. 1987 91 p Previously announced in IAA as A87-22449
(NASA-TM-89426; A-87098; NAS 1.15:89426) Avail: NTIS HC A05/MF A01 CSCL 01A

Wind-tunnel measurements of boundary-layer and wake velocity profiles and surface static pressure distributions are presented for a swept, circulation-control wing. The model is an aspect-ratio-four semispan wing mounted on the tunnel side wall at a sweep angle of 45 deg. A full-span, tangential, rearward blowing, circulation-control slot is located ahead of the trailing edge on the upper surface. Flow surveys were obtained at mid-semispan at freestream Mach numbers of 0.425 and 0.70. Boundary-layer profiles measured on the forward portions of the wing are approximately streamwise and two dimensional. The flow in the vicinity of the jet exit and in the near wake is highly three dimensional. The jet flow near the slot on the Coanda surface is directed normal to the slot. Near-wake surveys show large outboard flows at the center of the wake. At Mach 0.425 and a 5-deg angle of attack, a range of jet-blowing rates was found for which an abrupt transition from incipient separation to attached flow occurs in the boundary layer upstream of the slot. The variation in the lower-surface separation location with blowing rate was determined from boundary-layer measurements at Mach 0.425.
Author

N88-22014*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BIFURCATIONS IN UNSTEADY AERODYNAMICS-IMPLICATIONS FOR TESTING
GARY T. CHAPMAN and MURRAY TOBAK Mar. 1988 20 p
(NASA-TM-100083; A-88076; NAS 1.15:100083) Avail: NTIS HC A03/MF A01 CSCL 01A

The various forms of bifurcations that can occur between steady and unsteady aerodynamic flows are reviewed. Examples are provided to illustrate the various ways in which bifurcations may intervene to influence the outcome of dynamics tests involving unsteady aerodynamics. The presence of bifurcation phenomena in such tests must be taken into consideration to ensure the proper interpretation of results, and some recommendations are made to that end.
Author

N88-22015*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLOW MEASUREMENT MADE WITH A LASER VELOCIMETER ON A HELICOPTER MODEL IN FORWARD FLIGHT. VOLUME 3: RECTANGULAR PLANFORM BLADES AT AN ADVANCE RATIO OF 0.30
JOE W. ELLIOTT, SUSAN L. ALTHOFF, and RICHARD H. SAILEY (PRC Kentron, Inc., Hampton, Va.) Apr. 1988 390 p
(NASA-TM-100543; NAS 1.15:100543; AVSCOM-TM-88-B-006) Avail: NTIS HC A17/MF A01 CSCL 01A

An experimental investigation was conducted in the 14- by 22-Foot Subsonic Tunnel at NASA Langley Research Center to measure the inflow into a scale model helicopter rotor in forward flight (micron sub infinity = 0.30). The measurements were made with a two component Laser Velocimeter (LV) one chord above the plane formed by the path of the rotor tips (tip path plane). A conditional sampling technique was employed to determine the azimuthal position of the rotor at the time that each velocity measurement was made so that the azimuthal fluctuations in velocity could be determined. Measurements were made at a total of 180 separate locations in order to clearly define the inflow character. These data are presented without analysis. Author

N88-22016*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROCEDURES AND REQUIREMENTS FOR TESTING IN THE LANGLEY RESEARCH CENTER UNITARY PLAN WIND TUNNEL
DONALD L. WASSUM and CURTIS E. HYMAN, JR. (PRC Kentron, Inc., Hampton, Va.) Feb. 1988 53 p
(NASA-TM-100529; NAS 1.15:100529) Avail: NTIS HC A04/MF A01 CSCL 01A

Information is presented to assist those interested in conducting wind-tunnel testing within the Langley Unitary Plan Wind Tunnel. Procedures, requirements, forms and examples necessary for tunnel entry are included.
Author

N88-22017# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
TRENDS IN COMPUTATIONAL FLUID DYNAMICS (CFD) FOR AERONAUTICAL 3D STEADY APPLICATIONS: THE DUTCH SITUATION
J. W. BOERSTOEL, A. E. P. VELDMAN, J. VANDERVOOREN, and A. J. VANDERWEES 28 Jul. 1986 21 p Presented at the 25th Working Group on Computational Fluid Dynamics Meeting, Delft, The Netherlands, 20 Oct. 1986
(NLR-MP-86074-U; B8731726; ETN-88-92225) Avail: NTIS HC A03/MF A01

Developments in computational 3-D steady aerodynamics software focusing on the efficient aerodynamic design of the next generation of transport aircraft, are surveyed. The major aerodynamic problem areas accessible to computational aerodynamics are discussed. The coherence in computational methods development is explained by showing how the methods cover a growing part of the aircraft operating range. The development of the most advanced methods, based on the Euler and Reynolds-average Navier-Stokes equations, is outlined. Computing aspects are reviewed. ESA

N88-22018*# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
FLEXIWALL 3 SO: A SECOND ORDER PREDICTIVE STRATEGY FOR RAPID WALL ADJUSTMENT IN TWO-DIMENSIONAL COMPRESSIBLE FLOW
M. J. GOODYER and MICHAEL JUDD Jul. 1981 59 p
(Contract NSG7-172)
(NASA-CR-181662; NAS 1.26:181662) Avail: NTIS HC A04/MF A01 CSCL 01A

An improvement is presented for the 2-D strategies for adjustment of the flexible top and bottom walls of an Adaptive (Wind Tunnel) Wall Test Section (AWTS). This adjustment is part of the wall adaptation process to eliminate top and bottom wall interference at the source. The improvements to account for second order effects are described in mathematical detail. It is intended that these improvements should further minimize the necessary iterations in the wall adaptation process. An associated computer program written in BASIC is presented and several test cases run with this program are discussed. The strategy performs well for a theoretical test case but when applied to experimental AWTS data some discrepancies in the adapted wall shapes are found. Author

N88-22019*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POROUS WIND TUNNEL CORRECTIONS FOR COUNTERROTATION PROPELLER TESTING
GEORGE L. STEFKO and ROBERT J. JERACKI 1988 18 p Presented at the 15th Aerodynamic Testing Conference, San Diego, Calif., 18-20 May 1988; sponsored by AIAA
(NASA-TM-100873; E-4099; NAS 1.15:100873) Avail: NTIS HC A03/MF A01 CSCL 01B

Wind tunnel interference corrections have direct impact on measured propeller efficiency. A systematic series of wind tunnel tests was done in the porous-wall NASA Lewis 8- by 6-Foot Wind Tunnel to determine the wind tunnel interference corrections to the NASA Lewis counterrotation propeller test data. The test results were compared with calculations from a potential flow code to determine the interference corrections. At a Mach number of 0.8, the interference corrections resulted in a -0.008 Mach number correction which reduced the counterrotation propeller net efficiency data by 0.46 percent at the reduced Mach number. Additional wind tunnel tests were done to measure the effect of propeller thrust on wind tunnel wall interference. No wall interference corrections due to propeller thrust were found necessary for the high speed counterrotation propeller data obtained in the porous wall NASA Lewis 8- by 6-Foot Wind Tunnel. Author

N88-22241# Joint Publications Research Service, Arlington, Va.
INVESTIGATION OF SIDE-WALL EFFECTS IN WIND TUNNEL WITH SUPERCRITICAL AIRFOIL TESTING Abstract Only
CHAO GAO *In its* JPRS Report: Science and Technology. China p 50 11 Dec. 1987 Transl. into ENGLISH from Lixue Xuebao (Beijing, Peoples Republic of China), v. 19, no. 4, Jul. 1987 p 381-386
Avail: NTIS HC A06/MF A01

An investigation is presented of the side-wall effect in a two dimensional transonic wind tunnel with side-wall boundary layer suction around the model. The span of the airfoil model used in the experiments is larger than the width of the test section. Therefore, the model can be shifted laterally and the streamwise pressure distribution for different spanwise sections can be obtained. The test results show that, for supercritical flow, the application of side-wall suction will result in an improvement of spanwise uniformity of aerodynamics and a downstream movement of the shock wave. Author

N88-22243# Joint Publications Research Service, Arlington, Va.
THEORETICAL MODEL AND NUMERICAL SOLUTION FOR COMPRESSIBLE VISCOUS VORTEX CORES Abstract Only
BINGQIU LIN *In its* JPRS Report: Science and Technology. China p 59 11 Dec. 1987 Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, Peoples Republic of China), v. 5, no. 3, Sep. 1987 p 235-243 Original language document was announced in IAA as A88-14016
Avail: NTIS HC A06/MF A01

Based on the dimensional analysis, the parabolic equation of a compressible viscous vortex core was derived. A simpler numerical method described can be used to calculate the subsonic, transonic, and supersonic vortex motions. Numerical results for two examples are also shown, one for the expanding motion of the stable vortex and the other for the contracting motion of the stable vortex. Author

N88-22244# Joint Publications Research Service, Arlington, Va.
MIXED DIRECT-INVERSE PROBLEM OF TRANSONIC CASCADE Abstract Only
WEI LIU and MENGYU SHEN *In its* JPRS Report: Science and Technology. China p 60 11 Dec. 1987 Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, Peoples Republic of China), v. 5, no. 3, Sep. 1987 p 244-250 Original language document was announced in IAA as A88-14017
Avail: NTIS HC A06/MF A01

A computational method is used to solve the mixed direct-inverse problem of a transonic plane cascade. It is based on the finite volume method and solves Euler equations directly. In effect the flow field in which shocks exist can be studied. The present method can be used in a wider range then the transonic relaxation method. E.R.

N88-22859# National Aerospace Lab., Tokyo (Japan).
DESIGN METHOD FOR LAMINAR FLOW CONTROL OF TWO-DIMENSIONAL AIRFOILS IN INCOMPRESSIBLE FLOW. NUMERICAL STUDY OF LFC DESIGN CONCEPTS
YOJI ISHIDA Nov. 1986 16 p In JAPANESE; ENGLISH summary
(DE88-751809; NAL-TR-920) Avail: NTIS (US Sales Only) HC A03

A laminar flow control technology aims to greatly reduct the frictional resistance on the airfoil surface by retaining the laminar flow by stabilizing the boundary layer on the surface of the airfoil by sucking. It is an effective procedure to prepare, by calculation, a few design concepts with excellent characteristics and to carry out an experimental verification. The calculation method is composed of boundary layers for laminar, translational, and turbulent flow. Calculation of boundary layers put basis on Kellers box scheme (differential decomposition methods of boundary layer equation), and criterion of transition point used Cebeci-Smith's algebraic model. Both continuous and discrete models were used for suction. Effect of frictional resistance reduction, effect of dissipating suction, effect of sucking position, and hybrid laminar flow control were examined. This method seems useful for a parametric study of laminar flow control airfoil design. DOE

N88-22860# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Zellenaerodynamik.
A MULTILIFTING LINE METHOD AND ITS APPLICATION IN DESIGN AND ANALYSIS OF NONPLANAR WING CONFIGURATIONS Ph.D. Thesis - Technische Univ., Brunswick, Fed. Republic of Germany
KARL-HEINZ HORSTMANN Dec. 1987 148 p In GERMAN; ENGLISH summary
(DFVLR-FB-87-51; ISSN-0171-1342; ETN-88-92323) Avail: NTIS HC A07/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 45 DM

A calculation method for nonplanar wing geometries having discrete bound vortices at the 1/4-lines of panels is described. Instead of the discrete trailing vortices of the vortex lattice singularity model, a trailing vortex sheet having a continuously distributed vortex strength is employed. The bound vortex strength is a steady function of the spanwise position. This function is assumed to be parabolic on each panel, so the vortex strength of the trailing vortices has a linear behavior in spanwise direction. This singularity model is employed in an analysis and in a design method which allows the design of nonplanar wings having minimum induced drag. Calculations with different geometries show that the accuracy of the method for load distribution and induced drag is as good as that of lifting surface theories. ESA

N88-22861# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
EXPERIMENTAL INVESTIGATION OF THE TRANSONIC FLOW AT THE LEEWARD SIDE OF A DELTA WING AT HIGH INCIDENCE
Z. M. HOUTMAN and W. J. BANNINK Aug. 1987 43 p
(LR-518; B8733283; ETN-88-92461) Avail: NTIS HC A03/MF A01

The transonic flow field at the leeward side of a cropped delta wing with a sweep angle of 65 deg mounted on a cylindrical body having an ogival nose was studied at a free stream Mach number of 0.85 and at angles of incidence of 10 and 20 deg. Measurements show a complex flow containing dominant regions of vortices, embedded shock waves, and separations. In spite of the transonic flow and the presence of a body extending in front of the wing apex a large part of the flow field may be regarded as conical. At an incidence of 20 deg a strong shock wave is observed at 80 percent chord position terminating a region of locally supersonic flow; the shock stands across the wing symmetry plane but its actual shape is unknown. Evidence of a nonconical shock between the primary vortex and the wing surface, probably generated by the upstream influence of the cropped wing tips and of the trailing edge is obtained. Both shocks interfere quite strongly with the vortex system. Indications for a conical shock above the leading edge vortex are found. ESA

N88-22862*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Mechanics.
A NUMERICAL MODEL OF UNSTEADY, SUBSONIC AEROELASTIC BEHAVIOR Ph.D Thesis
THOMAS W. STRGANAC Aug. 1987 123 p Sponsored by NASA Original document contains color illustrations
(NASA-TM-101126; NAS 1.15:101126) Avail: NTIS HC A06/MF A01 CSCL 01A

A method for predicting unsteady, subsonic aeroelastic responses was developed. The technique accounts for aerodynamic nonlinearities associated with angles of attack, vortex-dominated flow, static deformations, and unsteady behavior. The fluid and the wing together are treated as a single dynamical system, and the equations of motion for the structure and flow field are integrated simultaneously and interactively in the time domain. The method employs an iterative scheme based on a predictor-corrector technique. The aerodynamic loads are computed by the general unsteady vortex-lattice method and are determined simultaneously with the motion of the wing. Because the unsteady vortex-lattice method predicts the wake as part of the solution, the history of the motion is taken into account; hysteresis is predicted. Two models are used to demonstrate the technique: a rigid wing on an elastic support experiencing plunge and pitch about the elastic axis, and an elastic wing rigidly supported at the root chord experiencing spanwise bending and twisting. The method can be readily extended to account for structural nonlinearities and/or substitute aerodynamic load models. The time domain solution coupled with the unsteady vortex-lattice method provides the capability of graphically depicting wing and wake motion. Author

N88-22863*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLOW MEASUREMENTS MADE WITH A LASER VELOCIMETER ON A HELICOPTER MODEL IN FORWARD FLIGHT. VOLUME 4: TAPERED PLANFORM BLADES AT AN ADVANCE RATIO OF 0.15
SUSAN L. ALTHOFF, JOE W. ELLIOTT, and RICHARD H. SAILEY (PRC Kentron, Inc., Hampton, Va.) Apr. 1988 322 p Also includes floppy disk format
(NASA-TM-100544; AVSCOM-TM-88-B-007; NAS 1.15:100544) Avail: NTIS HC A14/MF A01 CSCL 01A

An experimental investigation was conducted in the 14- by 22-Foot Subsonic Tunnel at NASA Langley Research Center to measure the inflow into the scale model helicopter rotor in forward flight (mu sub infinity = 0.15). The measurements were made with a two-component Laser Velocimeter (LV) one chord above the plane formed by the path of the rotor tips (tip path plane). A conditional sampling technique was employed to determine the position of the rotor at the time that each velocity measurement was made so that the azimuthal fluctuations in velocity could be determined. Measurements were made at a total of 146 separate locations in order to clearly define the inflow character. This data is presented herein without analysis. In order to increase the availability of the resulting data, both the mean and azimuthally dependent values are included as part of this report on two 5.25 inch floppy disks in MS-DOS format. Author

N88-22864*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ON THE VALIDATION OF A CODE AND A TURBULENCE MODEL APPROPRIATE TO CIRCULATION CONTROL AIRFOILS
J. R. VIEGAS, M. W. RUBESIN, and R. W. MACCORMACK (Stanford Univ., Calif.) Apr. 1988 25 p
(NASA-TM-100090; A-88127; NAS 1.15:100090) Avail: NTIS HC A03/MF A01 CSCL 01A

A computer code for calculating flow about a circulation control airfoil within a wind tunnel test section has been developed. This code is being validated for eventual use as an aid to design such airfoils. The concept of code validation being used is explained. The initial stages of the process have been accomplished. The present code has been applied to a low-subsonic, 2-D flow about a circulation control airfoil for which extensive data exist. Two basic turbulence models and variants thereof have been successfully introduced into the algorithm, the Baldwin-Lomax algebraic and the Jones-Launder two-equation models of turbulence. The variants include adding a history of the jet development for the algebraic model and adding streamwise curvature effects for both models. Numerical difficulties and difficulties in the validation process are discussed. Turbulence model and code improvements to proceed with the validation process are also discussed. Author

N88-22865*# Southampton Univ. (England).
AEROFOIL TESTING IN A SELF-STREAMLINING FLEXIBLE WALLED WIND TUNNEL Ph.D. Thesis - Jul. 1987
MARK CHARLES LEWIS Washington NASA May 1988 271 p

(Contract NSG-7172)
(NASA-CR-4128; NAS 1.26:4128) Avail: NTIS HC A12/MF A01 CSCL 01A

Two-dimensional self-streamlining flexible walled test sections eliminate, as far as experimentally possible, the top and bottom wall interference effects in transonic airfoil testing. The test section sidewalls are rigid, while the impervious top and bottom walls are flexible and contoured to streamline shapes by a system of jacks, without reference to the airfoil model. The concept of wall contouring to eliminate or minimize test section boundary interference in 2-D testing was first demonstrated by NPL in England during the early 40's. The transonic streamlining strategy proposed, developed and used by NPL has been compared with several modern strategies. The NPL strategy has proved to be surprisingly good at providing a wall interference-free test environment, giving model performance indistinguishable from that obtained using the modern strategies over a wide range of test conditions. In all previous investigations the achievement of wall streamlining in flexible walled test sections has been limited to test sections up to those resulting in the model's shock just extending to a streamlined wall. This work however, has also successfully demonstrated the feasibility of 2-D wall streamlining at test conditions where both model shocks have reached and penetrated through their respective flexible walls. Appropriate streamlining procedures have been established and are uncomplicated, enabling flexible walled test sections to cope easily with these high transonic flows. Author

N88-22866*# McDonnell Aircraft Co., St. Louis, Mo.
PROPULSION AND AIRFRAME AERODYNAMIC INTERACTIONS OF SUPERSONIC V/STOL CONFIGURATIONS. VOLUME 1: WIND TUNNEL TEST PRESSURE DATA REPORT
D. E. ZILZ and P. A. DEVEREAUX Sep. 1985 885 p
(Contract NAS2-10791)
(NASA-CR-177343-VOL-1; NAS 1.26:177343-VOL-1) Avail: NTIS HC A99/MF E03 CSCL 01A

A wind tunnel model of a supersonic V/STOL fighter configuration has been tested to measure the aerodynamic interaction effects which can result from geometrically close-coupled propulsion system/airframe components. The approach was to configure the model to represent two different test techniques. One was a conventional test technique composed of two test modes. In the Flow-Through mode, absolute configuration aerodynamics are measured, including inlet/airframe interactions. In the Jet-Effects mode, incremental nozzle/airframe interactions are measured. The other test technique is a propulsion simulator approach, where a sub-scale, externally powered engine is mounted in the model. This allows proper measurement of inlet/airframe and nozzle/airframe interactions simultaneously. This is Volume 1 of 2: Wind Tunnel Test Pressure Data Report. Author

N88-22867*# McDonnell Aircraft Co., St. Louis, Mo.
PROPULSION AND AIRFRAME AERODYNAMIC INTERACTIONS OF SUPERSONIC V/STOL CONFIGURATIONS. VOLUME 2: WIND TUNNEL TEST FORCE AND MOMENT DATA REPORT
D. E. ZILZ Sep. 1985 328 p
(Contract NAS2-10791)
(NASA-CR-177343-VOL-2; NAS 1.26:177343-VOL-2) Avail: NTIS HC A15/MF A01 CSCL 01A

A wind tunnel model of a supersonic V/STOL fighter configuration has been tested to measure the aerodynamic interaction effects which can result from geometrically close-coupled propulsion system/airframe components. The approach was to configure the model to represent two different test techniques. One was a conventional test technique composed of two test modes. In the Flow-Through mode, absolute configuration aerodynamics are measured, including inlet/airframe interactions. In the Jet-Effects mode, incremental nozzle/airframe interactions are measured. The other test technique is a propulsion simulator approach, where a sub-scale, externally powered engine is mounted in the model. This allows proper measurement of inlet/airframe and nozzle/airframe interactions simultaneously. This is Volume 2 of 2: Wind Tunnel Test Force and Moment Data Report. Author

N88-22868*# McDonnell Aircraft Co., St. Louis, Mo.
PROPULSION AND AIRFRAME AERODYNAMIC INTERACTIONS OF SUPERSONIC V/STOL CONFIGURATIONS. VOLUME 4: SUMMARY Final Report
D. E. ZILZ, H. W. WALLACE, and P. E. HILEY Sep. 1985 88 p
(Contract NAS2-10791)
(NASA-CR-177343-VOL-4; NAS 1.26:177343-VOL-4) Avail: NTIS HC A05/MF A01 CSCL 01A

A wind tunnel model of a supersonic V/STOL fighter configuration has been tested to measure the aerodynamic interaction effects which can result from geometrically close-coupled propulsion system/airframe components. The approach was to configure the model to represent two different test techniques. One was a conventional test technique composed of two test modes. In the Flow-Through mode, absolute configuration aerodynamics are measured, including inlet/airframe interactions. In the Jet-Effects mode, incremental nozzle/airframe interactions are measured. The other test technique is a propulsion simulator approach, where a sub-scale, externally powered engine is mounted in the model. This allows proper measurement of inlet/airframe and nozzle/airframe interactions simultaneously. This is Volume 4 of 4: Final Report- Summary. Author

N88-22869# Nagoya Univ. (Japan). Inst. of Plasma Physics.
ANALYSIS FOR HIGH COMPRESSIBLE SUPERSONIC FLOW IN CONVERGING NOZZLE
KEISHIRO NIU and TAKAYUKI AOKI (Tokyo Inst. of Tech., Yokahama, Japan) Feb. 1988 16 p
(IPPJ-860; ISSN-0469-4732) Avail: NTIS HC A03/MF A01

In a converging nozzle, fluid is shown to be compressed to a very high density, especially in the supersonic region, if the initial Mach number of the fluid is large. Thus it is shown that spherical implosion can be used as a method to make high density materials. Author

N88-22870# Michigan Univ., Ann Arbor. Dept. of Aerospace Engineering.
THE STRUCTURE OF SONIC UNDEREXPANDED TURBULENT AIR JETS IN STILL AIR Interim Report, 15 Jul. 1985 - 15 Aug. 1987
S. G. CHUECH, M. C. LAI, and G. M. FAETH Sep. 1987 118 p
(Contract N00014-85-K-0604)
(AD-A190856) Avail: NTIS HC A06/MF A01 CSCL 20D

Turbulent subsonic, sonic and underexpanded round air jets, in still air, were studied both theoretically and experimentally. The following measurements were made: shock-wave structure of the underexpanded jets, using flash and continuous schlieren photography; mean and fluctuating concentrations and mean static pressures, using laser-induced fluorescence; and mean and fluctuating streamwise velocities, using laser-Doppler anemometry. Analysis included: solution of the parabolized Navier-Stokes equations of motion; and use of effective adapted-jet exit conditions, to avoid the complexities of treating the shock-containing near field region of underexpanded jets. In both cases, turbulence properties were found using a k-epsilon turbulence model. Structure of the near-field region of the underexpanded jets was influenced by compressibility and turbulence levels at the jet exit. Mixing rates were reduced by compressibility when convective Mach numbers were greater than 0.5, in agreement with observations of Papamoschou and Roshko (1986); while increased turbulence levels at the jet exit increased mixing rates, which is a well-recognized effect for subsonic jets. The present parabolized Navier-Stokes method was successful for treating slug-flow exit conditions, but must be extended to treat effects of turbulent jet exit conditions. GRA

N88-22874# JAI Associates, Mountain View, Calif.
TIP VORTICES OF ISOLATED WINGS AND HELICOPTER ROTOR BLADES Final Report, Nov. 1984 - Nov. 1987
GANAPATHI R. SRINIVASAN Dec. 1987 86 p
(Contract DAAG29-85-C-0002)
(AD-A191336; JAIA-TR-87-01; R/D-5378-PH-01) Avail: NTIS HC A05/MF A01 CSCL 01A

Thin layer Navier-Stokes equations are solved numerically for simulating the flowfields of isolated wings and helicopter rotor blades with a particular emphasis on understanding the formation and roll-up of tip vortices in subsonic and transonic flows. Several test cases consisting of wings and rotor blades of different planforms have been considered to examine the influence of the tip-cap shape, the tip-planform, the freestream Mach number, and the effect of centrifugal forces of rotation. A fairly good definition of the formation and roll-up of the tip vortex is demonstrated for all the cases considered here. Finally, the calculated lift, drag and pitching-moment coefficients agree well with the experimentally determined values, where available. Alternate methods of simulating the hovering rotor flowfields in blade-fixed mode that have the circulation distribution as hovering blade are explored. The results and discussion are presented. GRA

N88-22875# Dayton Univ., Ohio. Research Inst.
AN INTEGRAL EQUATION FOR THE LINEARIZED SUPERSONIC FLOW OVER A WING Interim Report, Nov. 1986 - Aug. 1987
KARL G. GUDERLEY Feb. 1988 112 p
(Contract F33615-86-C-3200)
(AD-A191408; UDR-TR-87-91; AFWAL-TR-87-3097) Avail: NTIS HC A06/MF A01 CSCL 01A

In the first formulation, the integral equation for linearized steady supersonic flows appears in a form where it is necessary to approach the planform from above or below by a limiting process. In the present report, the problem is transformed analytically in such a manner that this limiting process no longer appears and that the resulting expressions are numerically tractable. It is believed that such a formulation gives more freedom to take the particularities of a given problem into account. The formulation is applied to compute the conical field which arises at the top of an airfoil. A possible numerical approach to the solution of the integral equation in the general case is described, but only in a rough outline. GRA

N88-23245*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
THE 2-D AND 3-D TIME MARCHING TRANSONIC POTENTIAL FLOW METHOD FOR PROPFANS
MARC H. WILLIAMS *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 263-271 May 1988
(Contract NAG3-499)
Avail: NTIS HC A20/MF A01 CSCL 01A

Recent efforts concentrated on the development of aerodynamic tools for the analysis of rotors at transonic speeds and of configurations involving relative rotation. Three distinct approaches were taken: (1) extension of the lifting surface method of Williams and Hwang (1986) to relative rotation; (2) development of a time marching linear potential method for counter rotation; and (3) development of 2 and 3 dimensional finite volume potential flow schemes for single rotation. Results from each of these approaches are described. Author

N88-23246*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
PROPFAN MODEL WIND TUNNEL AEROELASTIC RESEARCH RESULTS
ORAL MEHMED *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 273-286 May 1988
Avail: NTIS HC A20/MF A01 CSCL 01A

Some of the single rotation propfan model wind tunnel aeroelastic findings from the experimental part of this research program are described. These findings include results for unstalled or classical flutter, blade response from separated flow excitations, and blade response from aerodynamic excitations at angled inflow conditions. Author

N88-23248*# Duke Univ., Durham, N. C. Dept. of Mechanical Engineering and Materials Science.
REDUCED ORDER MODELS FOR NONLINEAR AERODYNAMICS
APARAJIT J. MAHAJAN, EARL H. DOWELL, and DONALD B. BLISS *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 299-308 May 1988
(Contract NAG3-724)
Avail: NTIS HC A20/MF A01 CSCL 01A

Reduced order models are needed for reliable, efficient and accurate prediction of aerodynamic forces to analyze fluid structure interaction problems in turbomachinery, including propfans. Here, a finite difference, time marching Navier-Stokes code is validated for unsteady airfoil motion by comparing results with those from classical potential flow. The Navier-Stokes code is then analyzed for calculation of primitive and exact estimates of eigenvalues and eigenvectors associated with fluid-airfoil interaction. A variational formulation for the Euler equations and Navier-Stokes equations will be the basis for reduction of order through an eigenvector transformation. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A88-37226* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CIVIL APPLICATIONS OF HIGH SPEED ROTORCRAFT AND POWERED LIFT AIRCRAFT CONFIGURATIONS
JAMES A. ALBERS and JOHN ZUK (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 627-651. Previously announced in STAR as N88-11643. refs
(SAE PAPER 872372)

Advanced subsonic vertical and short takeoff and landing (V/STOL) aircraft configurations offer new transportation options for civil applications. Described is a range of vehicles from low-disk to high-disk loading aircraft, including high-speed rotorcraft, V/STOL aircraft, and short takeoff and landing (STOL) aircraft. The status and advantages of the various configurations are described. Some of these show promise for relieving congestion in high population-density regions and providing transportation opportunities for low population-density regions. Author

A88-37227
POWERED-LIFT TRANSPORT AIRCRAFT CERTIFICATION CRITERIA STATUS
LARRY B. ANDRIESEN and JIM S. HONAKER (FAA, Fort Worth, TX) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 653-655.
(SAE PAPER 872376)

The development of FAA airworthiness certification standards for powered-lift aircraft is discussed, with emphasis on the tilt-rotor design. It is noted that the December 1986 powered lift draft criteria did not include standards for fly-by-wire and sidesticks. Difficulties in defining propulsion system failure include determining where the propulsion system starts and ends and what part of the propulsion system (engine, propeller, rotor, cross-shafting or remote thrust-producers used for control, etc.) can fail. The draft criteria did not include necessary requirements for handling qualities in the vertical axis. R.R.

A88-38756#
HELICOPTER AEROBATIC FLIGHT - THE TACTICAL SIGNIFICANCE
CHARLES A. PARLIER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 486-494. refs
(AIAA PAPER 88-2190)
While such state-of-the-art helicopters as the AH-64A have demonstrated significant aerobatic flight capability, as required for air-to-air combat, evidence of as-yet untapped maneuvering potential has emerged. Attention is given to capabilities for build-up/abort maneuvers, rolling, split-S, hammerhead, skewed loop, and loop maneuvers, and aerial combat in close-range encounters where there is little time for the pilot to react. Criteria for tactical high-angle maneuvering and the training requirements they suggest are discussed. O.C.

N88-22020# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS, BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 10 OF 1986 ACCIDENTS
31 Dec. 1987 421 p
(PB87-916912; NTSB/AAB-87/12) Avail: NTIS HC A01/MF A01; also available on subscription, North American Continent HC $185.00/year; all others write for quote CSCL 01C
The publication contains selected aircraft accident reports in Brief Format ocurring in U.S. civil and foreign aviation operations during Calendar Year 1986. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eighteen times each year. The Brief Format represents the facts, conditions, circumstances, and probable cause(s) for each accident. GRA

N88-22021# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: NORTH STAR AVIATION, INC., PA-32 RT-300, N39614 AND ALAMEDA AERO CLUB CESSNA 172, N75584, OAKLAND, CALIFORNIA, MARCH 31, 1987
27 Oct. 1987 46 p
(PB87-910412; NTSB/AAR-87/09) Avail: NTIS HC A03/MF A01; also available on subscription, North American Continent HC $60.00/year; all others write for quote CSCL 01C
The National Transportation Safety Board determines that the probable cause of the accident was the failure of each pilot-in-command to see and avoid the other aircraft, and the failure of the local controller to perceive the traffic conflict and issue traffic advisories. Contributing to the accident was the reduction in airspace separation between arriving and departing aircraft at Oakland's north field runways caused by the failure of the FAA to exercise its authority over airspace management. GRA

N88-22876# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Abteilung Meteorologisch Fernerkundung.
BIBLIOGRAPHY OF ICING ON AIRCRAFT (STATUS 1987)
KLAUS-PETER SCHICKEL and WERNER FUCHS Oct. 1987 38 p In GERMAN; ENGLISH summary
(DFVLR-MITT-87-18; ISSN-0176-7739; ETN-88-92310) Avail: NTIS HC A03/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 12.50 DM
Over 140 references on aircraft icing, particularly helicopters, are presented. The contributions of satellite imagery and personal computers to forecasting cloud icing and aircraft icing is stressed. ESA

N88-22877# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: MIDAIR COLLISION OF US ARMY U-21A, ARMY 18061 AND SACHS ELECTRIC COMPANY PIPER PA-31-350, N60SE, INDEPENDENCE, MISSOURI, JANUARY 20, 1987
3 Feb. 1988 61 p
(PB88-910401; NTSB-AAR-88-01) Avail: NTIS HC A04/MF A01; also available on subscription, North American Continent HC $70.00/year; all others write for quote CSCL 01C
The National Transportation Safety Board determines that the probable cause of the accident was the failure of the radar controllers to detect the conflict and to issue traffic advisories or a safety alert to the flightcrew of the U-21; deficiencies of the see and avoid concept as a primary means of collision avoidance; and the lack of automated redundancy in the air traffic control system to provide conflict detection between participating and nonparticipating aircraft. Author

N88-22878# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: MODENA, PENNSYLVANIA, MARCH 17, 1986; REDWATER, TEXAS, APRIL 4, 1986
20 Mar. 1988 19 p
(PB88-910403; NTSB-AAR-88-01-SUMM) Avail: NTIS HC A03/MF A01 CSCL 09C
This publication is a compilation of the reports of two separate aircraft accidents investigated by the National Transportation Safety Board. The accident locations and their dates are as follows: Modena, Pennsylvania, March 17, 1986, and Redwater, Texas, April 4, 1986. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A88-37376
INSTITUTE OF NAVIGATION, TECHNICAL MEETING, 1ST, COLORADO SPRINGS, CO, SEPT. 21-25, 1987, PROCEEDINGS
Meeting sponsored by the Institute of Navigation. Washington, DC, Institute of Navigation, 1987, 320 p. For individual items see A88-37377 to A88-37413.
Papers are presented on GPS phase III multichannel user equipment, GPS accuracy performance tests, and software architecture of the family of DOD standard GPS receivers. Also considered are a GPS hover position sensing system, GPS applications to carrier-based naval aircraft, and a potential GPS user architecture for the NASA Space Station based on Landsat 4/5 experience. Other topics include GPS integration with a low-cost inertial navigation unit, an integrated GPS/IRS design approach, and differential GPS with a sequencing receiver. Papers are also presented on a Kalman filter approach to self-contained GPS failure detection, receiver autonomous integrity monitoring using a 24-satellite GPS constellation, and GPS integrity monitoring for commercial applications using an IRS as a reference. R.R.

A88-37377#
GPS OVERVIEW -THE OPERATOR'S PERSPECTIVE
OWEN E. JENSEN (USAF, Washington, DC) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 1-3.
Maintenance of the Navstar GPS global navigation service by the USAF is discussed, in addition to shortcomings of the system. It is suggested that the USAF will provide periodic reports on the status of the entire system, identifying not only predicted areas of

reduced accuracy, but those areas effected by unforeseen spacecraft degradation as well. Projected uses of the GPS are discussed, such as reducing the time required for position location in geodetic applications and the performing of global surveys. R.R.

A88-37378#

GPS PHASE III MULTI-CHANNEL USER EQUIPMENT

J. F. VACHERLON, A. C. HUNEKE, G. M. KAISER, D. C. FORSETH, and J. H. JUSTICE (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 4-13. refs

The architecture of the multichannel GPS Phase III receivers, based on low-risk modifications to the Phase IIB design which are intended to improve system integration flexiblity, life cycle cost, and producibility, is discussed. The present receivers are based on five variations of a basic 2-channel and 5-channel P-code design with flexible I/O capability, and they can accommodate the integration needs of over 75 host vehicle applications. A unique stack-oriented adaptive processing system processor and complete selective availability/antispoofing capabilities are included in the system. Technology upgrades include the incorporation of low-power logic and the use of denser memory. R.R.

A88-37379#

FEATURES AND CAPABILITIES OF THE DOD STANDARD GPS RECEIVERS FOR AIRCRAFT AND SEABORNE APPLICATIONS

G. KRISHNAMURTI and D. E. GRAY (Rockwell International Corp., Cedar Rapids, IA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 14-22.

The operational capabilities, interfaces, and integration options provided by two 5-channel GPS receivers developed for aircraft and seaborne applications are discussed. Both receivers provide high-accuracy navigation solutions in both the aided and unaided modes and low time to first fixes under adverse jamming and dynamic conditions. Full denial of accuracy and antispoofing capabilites are included. High-accuracy time outputs and a complete area navigation function, including a rendezvous mode and mark capability with storage capacity for 209 waypoints, are provided by the receivers. The receivers also include comprehensive fault detection and isolation capabilities. R.R.

A88-37385#

RESULTS OF DYNAMIC TESTING OF THE USAF/ESMC GPS USER EQUIPMENT ABOARD THE RANGE TRACKING SHIPS USNS OBSERVATION ISLAND AND USNS REDSTONE

ANDREW NELSON (Pan Am World Services, Inc., Patrick AFB, FL) and EDWARD FRENCH (RCA International Service Co., Patrick AFB, FL) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 62-71. refs

Two systems consisting of a GPS receiver, navigational computer, and associated data recording devices and electronics for providing accurate positioning of the instrumentation ships USNS Redstone and USNS Observation Island are described. The positional accuracy of the Redstone and Observation Island GPS user equipment during multispacecraft coverage with good geometries was evaluated using a DM-43 autotape system as a reference. It is noted that initial positioning solutions using two or three space vehicles at the beginning of a tracking window are not presently within the + or - 15 m specifications in latitude and longitude due to an unsettled Kalman filter. R.R.

A88-37386#

REFERENCE TRAJECTORIES FROM GPS MEASUREMENTS

JAMES E. ROBBINS (General Dynamics Services Co., Yuma, AZ) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 72-80. USAF-sponsored research. refs

Reference trajectories for vehicles for which GPS measurements are available are determined which can be used a reference for the evaluation of GPS user-equipment and integrated host vehicle navigation. Three GPS solutions have been used in obtaining the reference trajectories: (1) a closed-form solution of the GPS pseudorange equations; (2) an unaided Kalman filter; and (3) an inertially-aided Kalman filter. It is noted that all of the solutions operate with or without differential GPS. Observed rms differences between the present system and the Yuma proving ground laser tracking system demonstrate that the system and the lasers both have at least a 5-m rms accuracy. R.R.

A88-37390#

A GPS HOVER POSITION SENSING SYSTEM

KEVIN C. SCHLOSSER and REX HOWE (U.S. Army, Aviation Systems Command, Fort Monmouth, NJ) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 103-108.

The test set up and results for an integrated GPS/inertial hover position sensing system are discussed. Initial flight test data suggest that the required hover position sensor accuracy is achievable using an integrated GPS/inertial system provided that modifications are made to the standard GPS navigation algorithms. Results point to the need for the GPS satellite selection algorithm to lock on to a constellation for the entire duration of the hover. Error growth due to ionospheric drift was noted over the three to four minute hover duration. R.R.

A88-37393#

A DIGITAL P-CODE GPS RECIEVER AND ITS APPLICATIONS TO EMBEDDED SYSTEMS

A. J. VAN DIERENDONCK, C. E. HEGER, D. C. WESTCOTT, and Q. D. HUA (Stanford Telecommunications, Inc., Santa Clara, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 130-139.

A GPS P-code receiver/navigator board set is described which can be used for embedding the GPS capability within other navigation systems or sensors, or in other avionics systems. The present high-performance digital design includes VLSI and surface acoustic wave technology, resulting in small size, reduced power dissipation, higher reliability, and lower cost. The use of VLSI also eliminates many implementation losses characteristic of analog, analog-digital, and other digital designs. The present receiver uses multiple correlators (three or more) in the receiver channels. R.R.

A88-37394#

THE CANADIAN MARCONI COMPANY GPS RECEIVER - ITS DEVELOPMENT, TEST, AND FUTURE

PATRICK J. HUI and JAMES M. BROWN (Canadian Marconi Co., Kanata, Canada) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 140-149. refs

The design methodology, design trade-offs, and equipment features of the CMA-786, a GPS navigation system using the Navstar/GPS standard positioning service, are described. The system is capable of acquiring and tracking the coarse-acquisition code from all satellites on the L1 (1575.42 MHz) frequency band. The CMA-786 design is based on a dual signal-processing system architecture, and the receiver uses an adaptive satellite sequencing scheme. The various modules are described in detail, along with the CMA-786 software. Flight testing of the system resulted in both a software upgrade and the replacement of the least squares filter with a Kalman filter. R.R.

A88-37397*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

HELICOPTER TERMINAL APPROACH USING DIFFERENTIAL GPS WITH VERTICAL-AXIS ENHANCEMENT

F. G. EDWARDS, R. A. PAIELLI, and D. M. HEGARTY (NASA, Ames Research Center, Moffett Field, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 163-170. refs

The NAVSTAR Global Positioning System (GPS) in differential mode (DGPS) has been shown to be least accurate in the vertical axis. The vertical axis also has the most stringent accuracy requirements for aircraft precision approach and landing. A series of flight tests were conducted to evaluate a concept for improving the DGPS vertical axis navigation performance. These tests incorporated augmentation sensors to aid the DGPS navigation solution during terminal approach operations. A GPS receiver was installed on board a NASA helicopter and interfaced with a real-time digital computer system. A reconfigurable navigation filter programmed in the digital computer provided an augmented DGPS solution, with selectable inputs from a low-cost vertical accelerometer, a barometric altimeter, and the aircraft attitude gyros. The reference aircraft position was determined by a laser tracker. Extensive post-test analysis was done to optimize the filter performance during the terminal approach operation. Test results show that baro-altimeter aiding can significantly improve vertical axis performance. Follow-on tests are planned for the optimized configurations. Author

A88-37399#
INTEGRATION OF GPS RECEIVERS INTO EXISTING INERTIAL NAVIGATION SYSTEMS
D. A. TAZARTES and J. G. MARK (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 176-183. refs

Many inertial navigation systems of both platform and ring laser strapdown types are currently in service. This paper discusses the possibility and desirability of incorporating a small GPS receiver in these systems. Advances in technology such as microprocessors, gate arrays and surface mount devices allow the existing INS electronics to be replaced in a reduced volume. The remaining space in many cases is sufficient to permit the insertion of a small GPS Receiver. Locating the GPS receiver in an inertial navigation system (INS) solves many of the usual system integration problems. Tight coupling between the GPS and INS can be achieved since data latency is minimized and well controlled. In such a configuration, rate aiding of the GPS is easily achieved. This approach also leads to greater flexibility and enhanced overall performance since all GPS and INS data are simultaneously available. While not providing the ultimate in redundancy, the integrated INS/GPS approach does offer greater simplicity with enhanced performance. This makes it a very attractive solution. Author

A88-37400#
A FULLY INTEGRATED GPS/DOPPLER/INERTIAL NAVIGATION SYSTEM
STEPHEN F. ROUNDS and JEAN M. CASEY (Singer Co., Electronic Systems Div., Wayne, NJ) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 184-187.

The ability of a Doppler system integrated with a GPS/inertial system to maintain system accuracy during periods of GPS outage has been demonstrated. Doppler system modelling is considered, in addition to the use of GPS/inertial data to calibrate the elements of the model using a Kalman filter. Trade-off studies on the use of a Doppler system vs the use of a higher accuracy INS indicate that the addition of the Doppler may be approximately equivalent to an INS improvement of 60 percent. R.R.

A88-37402#
GPS INTEGRATION WITH LOW-COST INERTIAL NAVIGATION UNIT
DONALD T. KNIGHT (Magnavox Advanced Products and Systems Co., Torrance, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 197-203.

A successful integration is described that involves a one-channel GPS receiver tightly coupled with a low-cost inertial navigation unit (INU). The combination is intended for low cost military applications. A 17-state Kalman navigation filter was used that performs in-flight calibration and alignment of the INU using GPS receiver measurements of pseudorange and delta range. By including INU gyro and accelerometer error states in the Kalman filter, the low-cost INU performs as well as units costing much more. Conversely, INU velocity data is used to extend the GPS receiver tracking threshold against jammers, and to improve reacquisition of signals after a loss. Sensor error models, Kalman filter design and system-level performance predictions are briefly described. Field test methodology is described, and field test results obtained to date are presented. Author

A88-37403#
T-33 AIRCRAFT DEMONSTRATION OF GPS AIDED INERTIAL NAVIGATION
DAVID E. FRAZIER, EUGENE A. MICKLE, JOHN T. NIELSON, and KENNETH W. RIGG (Boeing Aerospace Co., Seattle, WA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 204-211.

A Boeing Aerospace Company research project has been completed in which a single channel GPS receiver was integrated with a high quality inertial navigation system (INS). Aiding from the INS and a barometric altimeter was implemented to enable the GPS receiver to withstand satellite signal outages. Aiding also enabled the single channel receiver to be initialized during flight and to navigate using three satellites instead of four, as are normally required. The high quality INS provided good performance during extended periods of satellite outage. The resulting system has better accuracy than GPS alone as well as the jam immunity and responsiveness of inertial navigation. System tests were conducted in a Boeing-owned T-33 jet aircraft in Western Washington and at Yuma Proving Grounds. Earlier development and test activities were conducted in a mobile avionics lab, (a modified Greyhound bus). This effort is different from others, including earlier efforts by Boeing, in that it represents the first time that a single channel receiver has been flown at Yuma. The results support our assertion that a single channel receiver using INS aiding can perform as well as an unaided five channel set in a dynamic environment. Author

A88-37404#
AN INTEGRATED GPS/IRS DESIGN APPROACH
RANDOLPH G. HARTMAN (Honeywell, Inc., Air Transport Div., Saint Louis Park, MN) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 212-219.

The design approach and advantages of GPS/inertial reference system integration are discussed. Advantages of the integrated approach include enhanced satellite tracking, inertial vertical loop stabilization, GPS navigation during poor satellite coverage, in-flight inertial alignment, and reduced synchronization errors. The components of the system, a GPS antenna, a two-channel sequential GPS preprocesssing module, and a strapdown Schuler tuned laser inertial reference unit, are described in detail. Other topics discussed include GPS preprocessor software processing, satellite management, autonomous and hybrid GPS navigation, and inertial navigation software processing. R.R.

A88-37405#
INTEGRATION OF DIFFERENTIAL GPS WITH INS FOR PRECISE POSITION, ATTITUDE AND AZIMUTH DETERMINATION
A. K. AGGARWAL (Magnavox Advanced Products and Systems Co., Torrance, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings.

Washington, DC, Institute of Navigation, 1987, p. 220-227. Research sponsored by the McDonnell Douglas Astronautics Co. refs

The NAVSTAR Global Positioning System (GPS), currently being developed for the Department of Defense, is a space-based navigation system that will provide the user with precise position, velocity and time information on a 24-hour basis and in all-weather conditions at any point on the globe. Differential operation,, wherein a high quality, surveyed-in receiver installation determines satellite pseudorange errors and communicates them to nearby users, offers a promising technique for further improving the GPS position accuracy on a local scale. A GPS receiver, under differential operation and when integrated with an Inertial Measurement Unit (IMU) provides a very high quality navigation system for a variety of applications. The resulting navigation system overcomes many of the weaknesses of a stand-alone GPS or IMU by providing: (1) high rate/accuracy position and velocity estimates during dynamics, (2) the reduced position and velocity error growth during GPS signal outage, (3) improved jamming resistance through code loop aiding, and (4) the availability of very precise attitude and azimuth of the vehicle. This makes the Differential GPS/INS suitable for truth navigation systems, for calibration, and instrumentation.
Author

A88-37406#

DIFFERENTIAL GPS WITH A SEQUENCING RECEIVER

RALPH ESCHENBACH and ANIL TIWARI (Trimble Navigation, Sunnyvale, CA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 228-234.

Differential GPS tests have been conducted with a 10X GPS/Loran receiver modified to accept Radio Technical Commission for Maritime Service data. The 10X has a two-channel sequencing GPS receiver. Tests conducted for both zero and 12 meter baseline conditions show a mean position error of about 2 m with an rms of less than 3 m. It is noted that satellite switching had little effect on the performance of differential GPS, and that the Delta differential connections provided by the reference station made the ephemeris transition transparent to the user. R.R.

A88-37412#

GPS INTEGRITY MONITORING FOR COMMERCIAL APPLICATIONS USING AN IRS AS A REFERENCE

MATS A. BRENNER (Honeywell Inc., Air Transport Systems Div., Saint Louis Park, MN) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 277-286.

An integrated GPS/inertial reference system (IRS) approach for integrity monitoring in commercial applications is presented, with special attention being given to the soft-type failure (failures that cause the error in pseudorange to grow slowly). Simulation results provide values for the smallest detectable drift in pseudorange. Crucial factors which effect the performance are shown to be the time between update of the satellite health status and the selective availablity noise. If soft failure occurs in a satellite for which no redundant satellite information is available, the GPS/IRS Kalman filter will detect the failure using statistical data describing the error in measured pseudorange or delta-range values. R.R.

A88-37699

RADIO-ELECTRONIC EQUIPMENT OF AIRCRAFT: HANDBOOK [RADIOELEKTRONNOE OBORUDOVANIE LETATEL'NYKH APPARATOV: SPRAVOCHNIK]

ANDREI ANAN'EVICH SOSNOVSKII and IZIDOR ARONOVICH KHAIMOVICH Moscow, Izdatel'stvo Transport, 1987, 256 p. In Russian. refs

The functions of the radio-electronic equipment of commercial aircraft, the factors determining the makeup of the equipment, and the principles of combining components in equipment complexes are discussed. Detailed data are presented on communication, navigation, landing, and traffic control systems and their components. Particular attention is given to the principle of operation, technical characteristics and parameters, architecture, and the overall design and layout of airborne radio-electronic systems. V.L.

A88-38705#

RADARBET - A MULTIPLE TRAJECTORY ESTIMATOR USING AN EXPERT SYSTEM

L. A. SLEDJESKI and L. S. STONE (Grumman Data Systems Corp., Bethpage, NY) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 28-35.
(AIAA PAPER 88-2082)

'Radarbet', a nine-state Kalman filter-based trajectory estimator operating in real time for flight test applications, furnishes accurate trajectory data representing mission spatial positions, velocities, and accelerations for up to eight different aircraft simultaneously. These trajectory estimates can not only drive geographical displays, but will also provide real-time checkout of onboard navigation, radar, and weapons systems. Radarbet incorporates highly flexible mission reconfiguration capabilities. Operator interaction is kept to a minimum through the use of a high-level color graphics display and a rule-based expert system for real-time maintenance and filter stabilization. O.C.

A88-38714#

FLIGHT TEST IMAGERY - GETTING MORE FOR LESS

VAL D. VAUGHN and ROBERT A. LINDSAY (Unisys Corp., Defense Systems Div., Salt Lake City, UT) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 118-126. refs
(AIAA PAPER 88-2102)

An account is given of image compression techniques for the transmission of TV-quality real-time imagery, with a view to the achievable compression performance and the nature of hardware implementation problems. Attention is given to the vector quantization of imagery, outlining its implementation parameters for the case of an airborne image compression system that can transmit TV-quality video at rates as low as 1-15 Mbps. Implementation results are presented for an operating breadboard vector quantization system. O.C.

A88-38720#

JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM (JTIDS) CLASS 2 TERMINAL FLIGHT TEST

S. J. DOBRONSKI (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 162-170. refs
(AIAA PAPER 88-2119)

The DOD's Joint Tactical Information Distribution System (JTIDS) for improving the tactical coordination of U.S. forces furnishes users with selective information distribution, digital voice, relative navigation, hostile/friendly/unknown aircraft locations, and aircraft identification capabilities. JTIDS is a secure and jam-resistant TDMA system implemented through two classes of terminals. Attention is given to flight test results for the Class 2 Terminals, designed for use aboard ships, tactical aircraft, and mobile ground units. O.C.

A88-38726#

A NEW METHOD TO CONFIRM CATEGORY III AUTOLAND PERFORMANCE

HAROLD K. CHENEY and CANH T. PHAM (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 219-223.
(AIAA PAPER 88-2126)

Flight testing and certification of Category III autoland systems require the measurement of touchdown positions for numerous landings. XILS, a new computerized flight-test procedure, has been developed to efficiently calculate an aircraft's position during an instrument landing system (ILS) landing and rollout. This method uses glide slope and localizer deviations, radio altitude, inertial reference system (IRS) ground speed, and ILS geometry. It provides data of the longitudinal distance from the glide slope transmitter and lateral distance from the localizer beam's centerline. The input data needed to make the calculations are recorded on the test aircraft's data tape. The test method described has been successfully used to confirm Part 25 Category III autoland performance, and is faster and less expensive for obtaining autoland performance data than previous flight-test position-tracking procedures. This paper presents the equations and validation methods used by Douglas Aircraft Company to establish the procedure for autoland flight testing. Author

A88-38743#
AN AIRBORNE REALTIME DATA PROCESSING AND MONITORING SYSTEM FOR RESEARCH AIRCRAFT
A. REDEKER and P. VOERSMANN (Aerodata Flugmesstechnik GmbH, Brunswick, Federal Republic of Germany) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 361-367.
(AIAA PAPER 88-2165)

The paper presents the concept and realization of an open data system for airborne applications. It was layed out for the requirements of research aircraft, where sensor configurations and measuring instruments are varying from one experiment to another. All users have access to a pool of common sensor- and software resources. Special hard- and software interfaces have been defined for users to bring in their private sensor signals and computation algorithms. The system is suited for realtime processing, recording, and on-line monitoring of sensor data. It is the aim of the system design to enable the operator to perform quick error detection as well as to optimize flight conditions for an experiment. Examples for meteorological, flight-mechanical, and air-chemical applications are given. Author

A88-39135
ILS GLIDESCOPE EVALUATION OF IMPERFECT TERRAIN
M. M. POULOSE (National Airports Authority of India, Bangalore) and P. R. MAHAPATRA (Indian Institute of Science, Bangalore, India) IEEE Transactions on Aerospace and Electronics Systems (ISSN 0018-9251), vol. 24, March 1988, p. 186-191. refs

Instrument landing systems (ILS) are normally designed assuming the site around them to be flat. Uneven terrain results in undulations in the glidescope. In recent years, models have been evolved for predicting such aberrations as a simpler alternative to experimental methods. Such modeling normally assumes the ground to be fully conducting. A method is presented for considering imperfect terrain conductivity within the framework of the uniform theory of diffraction (UTD). First, a single impedance wedge formulation is developed to a form that resembles the standard form of UTD, with only one extra term in the diffraction coefficient. This extends the applicability of the standard UTD formulation and software packages to the case of the imperfectly conducting terrain. The method has been applied to a real airport site in India and improved agreement with measured glidescope parameters is demonstrated. I.E.

A88-39375
NAVIGATION BY SATELLITE - THE NEXT STEP FOR CIVIL AVIATION
GENEVIEVE EYDALEINE (CNES, Paris, France) ICAO Bulletin (ISSN 0018-8778), vol. 43, March 1988, p. 16-18.

The development of a global satellite navigation system is discussed. The GPS-Navstar system has the advantage of 100 m accuracy, but has discontinuities in service and has a relatively slow surveillance system. The RTCA has concluded that for GPS to be approved for civil use, three supplementary satellites would have to be launched into geostationary orbits, bringing the number of satellites used by GPS to 24. This increase would almost totally solve the problem of continuity of service and would enable the receiver to judge by itself the validity of information received by the six satellites in its sight. It would also make receivers much more complicated and would not solve the problem of cases where one or more satellites are not available. R.B.

A88-39813#
MEASUREMENT OF MULTIPATH PROPAGATION OF ELECTROMAGNETIC WAVES IN ACTUAL AIRPORT ENVIRONMENTS [MESSUNG DER MEHRWEGEAUSBREITUNG ELEKTROMAGNETISCHER WELLEN IN REALEN FLUGHAFENUMGEBUNGEN]
KLAUS-G. WESTPHAL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) (URSI and Nachrichtentechnische Gesellschaft, Gemeinsame Tagung, Kleinheubach, Federal Republic of Germany, Oct. 5-9, 1987) Kleinheubacher Berichte (ISSN 0343-5725), vol. 31, 1988, p. 517-526. In German.

The measurement of multipath propagation of electromagnetic waves during airport approach is described. A Doppler measurement apparatus is used which permits propagation in the VHF, L, and C frequency bands to be evaluated. Various methods of representing the measurement results are shown, and a concrete example is presented in which individual reflector types are distinguished from each other and described. C.D.

A88-40519
IMPLEMENTATION OF AERONAUTICAL MOBILE SATELLITE SERVICES (AMSSS) [LA MISE EN PLACE DES COMMUNICATIONS MOBILES AERONAUTIQUES PAR SATELLITES /AMSS/]
OLIVIER CAREL (Direction de la Navigation Aerienne, Service Technique, Paris, France) (Instituts de Navigation, Congres International, Sydney, Australia, Feb. 2-5, 1988) Navigation (Paris) (ISSN 0028-1530), vol. 36, April 1988, p. 208-215. In French.

Civil aviation systems for voice and data transmission such as VHF, HF, and ACARS/AIRCOM are reviewed, and current mobile systems are discussed. The IOAC future air navigation systems committee analysis of aeronautical mobile satellite systems indicates that VHF and secondary surveillance radar will continue to be used in the future, that HF will probably be discontinued, and that passenger telephone services using either satellite or cellular techniques will be developed. The increased use of coded data flow for technical applications is also predicted. R.R.

A88-40533#
CURRENT TREND OF DIGITAL MAP PROCESSING
NOBUO EBATO and SHIGERU KIMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 408, 1988, p. 26-29. In Japanese. refs

A88-41089
AIRBORNE DATA BASES - A QUIET REVOLUTION
JAMES E. TERPSTRA (Jeppesen Sanderson, Inc., Englewood, CO) Journal of Navigation (ISSN 0373-4633), vol. 41, May 1988, p. 249-255.

An overview of the use of the data base at Jeppesen Sanderson is given, stressing the NavData system and its core, the Flight Information Master Data Base. The discussion includes data base input and output, data edit checks, data base applications and plans for the future. On-board navigation computers using electronic navigation information are being implemented to relieve pilot workload and reduce error. The NavData services are also being applied to flight simulation. R.B.

N88-22883*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
DEVELOPMENT OF A MOBILE RESEARCH FLIGHT TEST SUPPORT CAPABILITY
DONALD C. RHEA and ARCHIE L. MOORE May 1988 12 p
Presented at the 4th Flight Test Conference, San Diego, Calif., 18-20 May 1988

(NASA-TM-100428; H-1456; NAS 1.15:100428; AIAA-88-2087)
Avail: NTIS HC A03/MF A01 CSCL 14B

This paper presents the approach taken by the NASA Western Aeronautical Test Range (WATR) of the Ames Research Center to develop and utilize mobile systems to satisfy unique real-time research flight test requirements of research projects such as the advanced fighter technology integration (AFTI)F-16, YAV-8B Harrier, F-18 high-alpha research vehicle (HARV), XV-15, and the UH-60 Black Hawk. The approach taken is cost-effective, staff efficient, technologically current, and provides a safe and effective research flight test environment to support a highly complex set of real-time requirements including the areas of tracking and data acquisition, communications (audio and video) and real-time processing and display, postmission processing, and command uplink. The development of this capability has been in response to the need for rapid deployment at varied site locations with full real-time computations and display capability. This paper will discuss the requirements, implementation and growth plan for mobile systems development within the NASA Western Aeronautical Test Range. Author

N88-22884*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.

ANALYSIS OF A RANGE ESTIMATOR WHICH USES MLS ANGLE MEASUREMENTS Final Report

DAVID R. DOWNING and DENNIS LINSE Jul. 1987 81 p
(Contract NAG1-490)
(NASA-CR-182896; NAS 1.26:182896; KU-FRL-671-1) Avail: NTIS HC A05/MF A01 CSCL 17G

A concept that uses the azimuth signal from a microwave landing system (MLS) combined with onboard airspeed and heading data to estimate the horizontal range to the runway threshold is investigated. The absolute range error is evaluated for trajectories typical of General Aviation (GA) and commercial airline operations (CAO). These include constant intercept angles for GA and CAO, and complex curved trajectories for CAO. It is found that range errors of 4000 to 6000 feet at the entry of MLS coverage which then reduce to 1000-foot errors at runway centerline intercept are possible for GA operations. For CAO, errors at entry into MLS coverage of 2000 feet which reduce to 300 feet at runway centerline interception are possible. Author

N88-22886*# Alphatech, Inc., Burlington, Mass.

EXPANDED ENVELOPE CONCEPTS FOR AIRCRAFT CONTROL-ELEMENT FAILURE DETECTION AND IDENTIFICATION Final Report

JEROLD L. WEISS and JOHN Y. HSU Jun. 1988 100 p
(Contract NAS1-18004)
(NASA-CR-181664; NAS 1.26:181664; TR-378) Avail: NTIS HC A05/MF A01 CSCL 17G

The purpose of this effort was to develop and demonstrate concepts for expanding the envelope of failure detection and isolation (FDI) algorithms for aircraft-path failures. An algorithm which uses analytic-redundancy in the form of aerodynamic force and moment balance equations was used. Because aircraft-path FDI uses analytical models, there is a tradeoff between accuracy and the ability to detect and isolate failures. For single flight condition operation, design and analysis methods are developed to deal with this robustness problem. When the departure from the single flight condition is significant, algorithm adaptation is necessary. Adaptation requirements for the residual generation portion of the FDI algorithm are interpreted as the need for accurate, large-motion aero-models, over a broad range of velocity and altitude conditions. For the decision-making part of the algorithm, adaptation may require modifications to filtering operations, thresholds, and projection vectors that define the various hypothesis tests performed in the decision mechanism. Methods of obtaining and evaluating adequate residual generation and decision-making designs have been developed. The application of the residual generation ideas to a high-performance fighter is demonstrated by developing adaptive residuals for the AFTI-F-16 and simulating their behavior under a variety of maneuvers using the results of a NASA F-16 simulation. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-37183

THE HIGH TECHNOLOGY TEST BED PROGRAM - AN OVERVIEW

H. W. COPELAND, JR. and S. K. HOFFMANN (Lockheed-Georgia Co., Marietta) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 101-103.
(SAE PAPER 872312)

Tactical Airlifters in the battlefield of the future will be required to operate on unprepared or damaged runways in all weather conditions without navigational or landing aids. Lockheed is addressing technologies required for these missions in an independent research and development program using a highly modified commercial C-130 aircraft as the technology integration focal point - a 'Flying Laboratory'. The HTTB Program addresses the major technology areas of advanced short takeoff and landing, survivability, advanced cockpit, and electronic systems. The Program goal is to develop systems to support autonomous operations into a 1500-foot landing area, up to and including a 50-foot obstacle at the runway threshold. Author

A88-37184 De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).

A REVIEW OF THE DE HAVILLAND AUGMENTOR-WING POWERED-LIFT CONCEPT AND ITS FUTURE APPLICATIONS

J. E. FARBRIDGE (de Havilland Aircraft Company of Canada, Downsview) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 105-116. Research supported by the Canadian Department of Industry, Trade and Commerce, DND, and NASA. refs
(SAE PAPER 872313)

A development history is presented for the augmentor wing powered-lift concept from the mid-1960s to the present. The augmentor wing concept employs a thick, compound or multielement airfoil wing section. Thickness/chord is up to 24 percent, and coefficient of lift above 0.6 for cruise Mach numbers of the order of 0.7. Transport aircraft incorporating these technologies can achieve ultrashort takeoff and landing capabilities on the basis of no more thrust than that installed for cruise. O.C.

A88-37185

PERFORMANCE FLIGHT TESTING OF A SINGLE ENGINE POWERED LIFT AIRCRAFT

RALPH D. KIMBERLIN (Tennessee, University, Tullahoma) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 117-137.
(SAE PAPER 872314)

This paper describes a low cost flight test program and presents the results for evaluating the performance of the Ball-Bartoe JETWING upper surface blown powered lift aircraft with and without the thrust augmenting ejector installed. The program included a ground test series for thrust calibration by dynamometer and by measuring the velocity profile with laser velocimeter followed by performance flight testing to obtain lift coefficient vs. angle of attack and lift coefficient vs. excess thrust coefficient. Stability and handling characteristics were also evaluated. Flight test results when compared with wind tunnel data generally showed good agreement although the lift curve slope obtained by flight test is somewhat less than that from wind tunnel primary testing because of inaccuracies involved in measuring angle of attack in flight. Author

A88-37186*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

QUIET SHORT-HAUL RESEARCH AIRCRAFT - A SUMMARY OF FLIGHT RESEARCH SINCE 1981

DENNIS W. RIDDLE, VICTOR C. STEVENS, and JOSEPH C. EPPEL (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 139-163. refs
(SAE PAPER 872315)

The Quiet Short-Haul Research Aircraft (QSRA), designed for flight investigation into powered-lift terminal area operations, first flew in 1978 and has flown 600 hours since. This report summarizes QSRA research since 1981. Numerous aerodynamic flight experiments have been conducted including research with an advanced concept stability and control augmentation and pilot display system for category III instrument landings. An electromechanical actuator system was flown to assess performance and reliability. A second ground-based test was conducted to further evaluate circulation-control-wing/upper-surface-blowing performance. QSRA technology has been transferred through reports, guest pilot evaluations and airshow participation. QSRA future research thoughts and an extensive report bibliography are also presented. Author

A88-37187* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

FLIGHT EVALUATION OF AN INTEGRATED CONTROL AND DISPLAY SYSTEM FOR HIGH-PRECISION MANUAL LANDING FLARE OF POWERED-LIFT STOL AIRCRAFT

CHARLES S. HYNES, GORDON H. HARDY (NASA, Ames Research Center, Moffett Field, CA), and THOMAS J. KAISERSATT IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 165-180. refs
(SAE PAPER 872316)

An account is given of the features and performance of a manual landing flare and touchdown system capable of great precision, as demonstrated by its installation in the NASA Quiet Short-haul Research Aircraft (QSRA). The integrated cockpit display and closed-loop control employed constitutes a trajectory-augmentation system that extends QSRA flight control from augmentation of altitude, flight path angle, and airspeed, to the augmentation of the trajectory itself. The + or - 18 ft touchdown dispersion achieved is approximately equal to that obtained during aircraft carrier trials of the same aircraft. O.C.

A88-37188

SOME TOPICS OF ASKA'S FLIGHT TEST RESULTS AND ITS FUTURE PLAN

TOSHIO BANDO, YOSHIO HAYASHI (National Aerospace Laboratory, Chofu, Japan), OSAMU KOBAYASHI, and ISAO KAGEYAMA (Kawasaki Heavy Industries, Ltd., Kobe, Japan) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 181-187. refs
(SAE PAPER 872317)

The quiet STOL research airplane ('ASKA') was developed as a research aircraft that would provide high levels of STOL performance at low levels of community noise. The ASKA is a C-1 tactical transport, modified to incorporate an Upper Surface Blowing (USB) type propulsive-lift system. Attention is given to the major subjects in evaluation of a newly developed engine, the actual proof of the structure, confirmation of different avionics systems, and documenting of fundamental flying quality and performance. Author

A88-37189

V/STOL AND THE ROYAL AIR FORCE

G. C. WILLIAMS (Ministry of Defence, London, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 189-193.
(SAE PAPER 872319)

THE ROYAL AIR FORCE was the first military organization to deploy a fixed-wing vertical/short take-off and landing aircraft - the British Aerospace Harrier. This paper describes the Royal Air Force's concept of operations for its current force of Harrier GR3s and sets out the advantages of the new Harrier GR5. Finally, it discusses the future of V/STOL with particular regard to Royal Air Force interest in the proposed Advanced Short Take-Off and Vertical Landing aircraft. Author

A88-37190

NEAR TERM ENHANCEMENTS OF THE AV-8B HARRIER II

ROGER H. MATHEWS (McDonnell Douglas Corp., Saint Louis, MO) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 195-200.
(SAE PAPER 872321)

Major upgrade items of the AV-8B Harrier II, a powered lift V/STOL, are considered, and the development of a radar equipped Harrier II is discussed. A digital engine control system has been designed and tested which requires fewer maintenance man hours per operating hour and provides reduced life cycle cost. The night attack suite consists of a navigation FLIR, a digital moving map, a wide field-of-view HUD, night vision goggle (NVG) compatible lighting, and 'cat's eyes' NVGs. Objectives of the new F402-RR-408 engine are to double the time before overhaul to 1000 hours, improve maintainability through modular construction, and increase thrust at elevated ambient temperatures. R.R.

A88-37202

PROPULSION/AERODYNAMIC INTEGRATION IN ASTOVL COMBAT AIRCRAFT

GEORGE M. APPLEYARD (British Aerospace, PLC, Military Aircraft Div., Brough, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 337-348. Research supported by the Ministry of Defence Procurement Executive. refs
(SAE PAPER 872333)

The provision of STOVL capability and a Supersonic capability in a small combat aircraft simultaneously introduces design and operational penalties, freedoms and complexities. The respective minimization, exploitation, and simplification of these represents a unique challenge, which must be met in order to maximize overall cost-effectiveness. The key to this lies in the full exploitation of the potential for powerplant/airframe integration of the advanced STOVL aircraft, via the Integrated Flight/Powerplant Control System (IFPCS). The overall design philosophy and control strategies of the IFPCS are highlighted and discussed with particular reference to the single-engined vectoring nozzle aircraft. These include: (1) controlling the combination of propulsive thrust vector and aerodynamic force vector to achieve optimum aircraft response and optimum aircraft performance; (2) controlling the manner in which the powerplant generates the required thrust vector in order to achieve maximum powerplant performance consistent with safe and reliable engine operation. Author

A88-37204

THE APPLICATION OF CIRCULATION CONTROL PNEUMATIC TECHNOLOGY TO POWERED-LIFT STOL AIRCRAFT

ROBERT J. ENGLAR (Lockheed Aeronautical Systems Co., Marietta, GA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 357-369. refs
(SAE PAPER 872335)

The flow-entraining capability of the Circulation Control Wing blown high-lift system has been synergistically combined with upper-surface-mounted engines to provide an even stronger STOL potential. The resulting configurations generate very high supercirculation lift plus a vertical component of pneumatically-deflected engine thrust. Small-scale wind-tunnel and full-scale static thrust-deflection tests have verified these concepts by confirming thrust deflections of greater than 90 deg produced pneumatically by nonmoving aerodynamic surfaces. High lift can be maintained while interchanging thrust recovery and thrust offset for optimum STOL performance, as well as for simplified heavy-lift or overload capability. Author

A88-37218
RESULTS OF A PRECISION HOVER SIMULATION ON THE ONE-TO-ONE MOTION LARGE AMPLITUDE RESEARCH SIMULATOR
MARSHALL S. HYNES (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 519-530. refs
(SAE PAPER 872356)

A piloted simulation was conducted to: evaluate attitude response bandwidth as a predictor of V/STOL hover flying qualities, validate a unique convolution integral simulation technique (CONVO), and qualitatively assess the one-to-one motion characteristics of the Grumman Large Amplitude Research Simulator (LARS). Handling qualities ratings demonstrated good correlation with attitude response bandwidth for both attitude command and rate command response types, however, a minimum damping requirement is necessary to supplement the bandwidth requirement for attitude command responses. Formal validation of the CONVO technique was not possible due to inaccurate modeling of the Grumman V/STOL Design 698, however, CONVO fidelity for the bandwidth investigation was satisfactory. Comparisons of pilot evaluations of the Design 698 on LARS and the NASA Ames VMS show LARS evaluations to be much worse due to high controller sensitivity. Author

A88-37223
SPECIAL REPORT ON BELL ACAP FULL-SCALE AIRCRAFT CRASH TEST
JAMES D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) and L. T. MAZZA (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 575-587. refs
(SAE PAPER 872362)

The results of a full-scale aircraft crash test of the Bell ACAP vehicle, conducted on August 27, 1987, are examined. The Bell ACAP was developed under a research program aimed specifically at demonstrating the technology advancement offered by composite materials when used in both primary and secondary airframe structures. Test results demonstrated that the aircraft successfully met the U.S. Army's stringent crash survivability requirements of 50-ft/s resultant ground impact velocity at an aircraft attitude of 10-deg roll and 10-deg nose-up pitch without any apparent serious injuries to the occupants. Namely, the overhead transmission mass was retained, the protective shell structure was maintained, the controlled seat stroking remained within limits at all locations, and the fuel was contained. Comparisons of test results with the KRASH computer simulation showed good agreement. I.S.

A88-37224
TECHNOLOGY FOR ADVANCED HELICOPTERS
W. EUAN HOOPER (Boeing Helicopter Co., Philadelphia, PA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 589-596. refs
(SAE PAPER 872370)

The recent history of helicopter technology is recalled, and the current status and future trends are surveyed and illustrated with extensive drawings and diagrams. The analysis and recommendations of a 1961 review (Harris, 1961) are briefly summarized and contrasted with the present emphases on vibration, noise, and R&M factors. Particular attention is given to the application of advanced CFM to increase speed, reduce vibration (via improved modeling of rotor loading and optimization of aerodynamics and structures), and avoid noise due to blade-vortex interaction and shock delocalization. Also discussed are the improved efficiency and reliability obtained by using advanced composite materials, efforts to produce propulsion systems with lower fuel consumption and higher thrust/weight ratios, and the performance of the Model 360 Advanced Technology Demonstrator helicopter. T.K.

A88-37229
CONFIGURATION E-7 SUPERSONIC STOVL FIGHTER/ATTACK TECHNOLOGY PROGRAM
JOHN E. JENISTA and ARTHUR E. SHERIDAN (General Dynamics Corp., Fort Worth, TX) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 669-677.
(SAE PAPER 872379)

The program covering the design and early technology development of Configuration E-7, a supersonic STOVL Fighter/Attack aircraft is described. This aircraft uses the ejector principle to augment engine fan air for vertical lift. The initial design objectives selected in 1980 are listed and discussed. Some design considerations applicable to the propulsion concept and the chosen configuration are mentioned. The test program accomplished thus far, including wind tunnel models plus other test articles and activities is outlined. The program has proceeded without major technologicl obstacles and a full-scale engine-powered model will soon be ready for test. Author

A88-37230
APPLYING VECTORED THRUST V/STOL EXPERIENCE IN SUPERSONIC DESIGNS
MICHAEL MANSELL (British Aerospace PLC, London, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 679-690.
(SAE PAPER 872381)

Design features of a vectored thrust V/STOL aircraft are discussed, and the operational advantages of vectored thrust that should be considered in the design of supersonic V/STOL fighter aircraft are reviewed. Advantages of vectored thrust with plenum chamber burning (PCB) for combat are discussed which are related to the use of thrust vectoring in forward flight (increasing agility and maneuverability) and the exploitation of the sky-jump launch. A V/STOL ground effects facility to study environmental and aircraft problems related to the use of PCB to enhance vertical lift performance is also described. R.R.

A88-37231
A SUPERSONIC DESIGN WITH V/STOL CAPABILITY
P. W. LIDDELL (British Aerospace PLC, Military Aircraft Div., Preston, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 691-703.
(SAE PAPER 872382)

After presenting a development history for the P103 STOVL supersonic flight-capable military aircraft concept, attention is given to the results obtained to date by a comprehensive wind tunnel study of its near-ground aerodynamics. P103 is a two-RB 199 engine-based tilt-nacelle canard configuration. An account is given of P103's combat modeling and simulation results and hover-condition hot gas reingestion characteristics. The configuration is noted to exhibit low supersonic drag, good transonic characteristics, high maximum speed, and good STOVL controllability with the nacelles fully tilted. O.C.

A88-37232
THE F-15 STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR (S/MTD) PROGRAM
FRANKLIN D. ROBERTS (McDonnell Douglas Corp., Saint Louis, MO) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 705-714.
(Contract F33615-84-C-3015)
(SAE PAPER 872383)
The incorporation of four new technologies into modern fighter design is considered: (1) a two-dimensional vectoring/reversing nozzle; (2) integrated flight/propulsion control; (3) rough/soft field STOL landing gear; and (4) an advance pilot/vehicle interface. A program to study these technologies using a modified F-15 STOL aircraft is described. Fortran simulations were conducted to evaluate control laws and cockpit displays. Wind tunnel tests, aircraft ground test, and projected flight tests are also discussed. The goal is to achieve operation from a 1500 x 50 foot runway. R.R.

A88-37234* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
USING FREQUENCY-DOMAIN METHODS TO IDENTIFY XV-15 AEROELASTIC MODES
C. W. ACREE, JR. (NASA, Ames Research Center, Moffett Field, CA) and MARK B. TISCHLER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 721-733. Previously announced in STAR as N88-17646. refs
(SAE PAPER 872385)
The XV-15 Tilt-Rotor wing has six major aeroelastic modes that are close in frequency. To precisely excite individual modes during flight test, dual flaperon exciters with automatic frequency-sweep controls were installed. The resulting structural data were analyzed in the frequency domain (Fourier transformed) with cross spectral and transfer function methods. Modal frequencies and damping were determined by performing curve fits to transfer function magnitude and phase data and to cross spectral magnitude data. Results are given for the XV-15 with its original metal rotor blades. Frequency and damping values are also compared with earlier predictions. Author

A88-37703
FLIGHT FATIGUE TESTING OF HELICOPTERS [LETNYE PROCHNOSTNYE ISPYTANIIA VERTOLETOV]
ROSTISLAV ALEKSANDRO MIKHEEV, VIKTOR SEMENOVICH LOSEV, and ALEKSANDR VLADIMIROV BUBNOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 128 p. In Russian. refs
Methods for the flight fatigue testing of helicopters and the required metrological support are reviewed. In particular, attention is given to a systems approach to flight fatigue testing, characteristics of the fatigue loading of helicopter components, dynamic instability, and safety considerations during testing. The discussion also covers the airborne and ground-based components of the data processing and measurement system, measurements of the rotor forces and moments, loading of the chassis, fuselage, and stabilizer, and vibration testing and analysis. V.L.

A88-38352
ALMOST ALL COMPOSITE HELICOPTER
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, May 1988, p. 15-18.
The 'Model 360' helicopter, which is powered by two 4200-shp turboshaft engines, combines the extensive use of advanced composite materials with modularized assembly techniques to serve as a technology validation platform for next-generation rotorcraft technology. Advanced composites are employed not only in such typical structures as the rotor blades and hubs, and such attractive candidates for further application as the fuselage structure, but also the altogether novel main beams and retractable bellcranks of the landing gear. The airframe consists of five major subsystem modules, including the tunnel, cockpit, fuselage, nose enclosure, and cabin floor/fuel-tank assembly. O.C.

A88-38353
RADIAL TIRES FOR AIRCRAFT?
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, May 1988, p. 21-23.
Over the last several years, such military aircraft as the F-15E and F-16, as well as Airbus-family commercial aircraft, have been using radial rather than bias-ply tires; the primary structural difference between the two being that, in a radial tire, the casing is surrounded circumferentially with belts of textile cords. The radial design results in lower shear stresses, weight savings, a greater spring rate, lower polar moment of inertia, superior cornering behavior, lower load deflection, and greater antiskid mechanism compatibility. O.C.

A88-38696
NOTAR - THE TAIL THAT WAGS THE DOG
MARK LAMBERT Interavia (ISSN 0020-5168), vol. 43, April 1988, p. 311, 312, 315.
The 'no tail rotor', or NOTAR system of ducted fan air, replacing the conventional helicopter tail rotor, has been implemented in a prototype OH-6 helicopter, and is intended for production incorporation into MD-500 series civil helicopters. Directional power is very high; the turning inertia of the prototype was twice as great as that of the conventional OH-6, so that turns 'on the spot' could be flown with virtually constant pedal position. The NOTAR boom used is constructed of composites, although the Coanda effect generated by the boom can be retained with much rougher surfaces. O.C.

A88-38701
AIAA FLIGHT TEST CONFERENCE, 4TH, SAN DIEGO, CA, MAY 18-20, 1988, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 563 p. For individual items see A88-38702 to A88-38763.
The present conference discusses NASA Ames-Dryden Flight Research Facility aircraft flight flutter testing, the Radarbet expert system-based multiple trajectory estimator, numerical filtering techniques for noise reduction in digital telemetry, 'skunk works' prototyping, the NASA Integrated Test Facility and its impact on flight research, a flight test approach to pilot workload assessment, AFTI/F-111 Mission Adaptive Wing flight research, the European Fighter Aircraft program, and a real-time aerodynamic analysis system for use in flight. Also discussed are stability flight test verification by modal separation, air-to-air combat development of the AH-64A Apache, a Space Shuttle crew escape tube study, a real-time flight performance analysis technique for the X-29A, a National Space Test Range, diagnostics design requirements for integrated avionics subsystems, maintainability as a design parameter, the tactical significance of helicopter aerobatics, and the development of a mobile flight test support facility. O.C.

A88-38702*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
AIRCRAFT FLIGHT FLUTTER TESTING AT THE NASA AMES-DRYDEN FLIGHT RESEARCH FACILITY
MICHAEL W. KEHOE (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1-14. refs
(AIAA PAPER 88-2075)
Many parameter identification techniques have been used at the NASA Ames Research Center, Dryden Flight Research Facility at Edwards Air Force Base to determine the aeroelastic stability of new and modified research vehicles in flight. This paper presents a summary of each technique used with emphasis on fast Fourier transform methods. Experiences gained from application of these techniques to various flight test programs are discussed. Also presented are data-smoothing techniques used for test data

distorted by noise. Data are presented for various aircraft to demonstrate the accuracy of each parameter identification technique discussed. Author

A88-38703#

AUTOLAND TESTING - PUSHING THE (BOTTOM) EDGE OF THE ENVELOPE

F. PARLINI (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 15-20. refs
(AIAA PAPER 88-2076)

Automatic landing of aircraft in poor visibility conditions, or 'autoland', involves an autopilot's capture of the localizer radio beam as the aircraft approaches a landing field; after one or more turning maneuvers, the aircraft is aligned with the landing field's centerline and initiates its 2.5-3.0 deg glideslope. An account is presently given of the test methods and instrumentation required for expansion and certification of autoland systems' operational envelope. O.C.

A88-38704#

F-15E FLIGHT TEST PROGRAM OVERVIEW - MARCH 1988

J. L. ROBERTS (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 21-27.
(AIAA PAPER 88-2077)

The F-15E aircraft is the latest derivative of the successful McDonnell-Douglas F-15 fighter series. This dual role aircraft is designed for the deep interdiction, night, air-to-ground mission while retaining its superb air-to-air capability. This overview of the F-15E flight test program presents general results to date and the test program concept including customer and contractor roles and responsibilities. The flight test program has achieved over 200 flights and 400 flight hours in the initial 14 calendar months utilizing two test aircraft. The program has been conducted within a combined test force structure with both contractor and USAF aircrews. Currently, the specification compliance phase of Development Test and Evaluation (DT&E) is nearing completion. Follow-on customer DT&E and Operational Test and Evaluation (OT&E) are scheduled to begin in the summer of 1988. Author

A88-38709#

T-46A FINAL REPORT

WENDELL H. SHAWLER (National Test Pilot School, Mojave, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 65-71.
(AIAA PAPER 88-2092)

The T-46 flight test program was terminated on March 13, 1987. In the final days the flutter envelope was expanded, the 80 percent loads tests both positive and negative were completed, the flight control system was finalized, most of the handling qualities test were completed and a significant part of the I.O.T.& E. (Initial Operational Test and Evaluation) was completed with the two test aircraft and the first production aircraft. A summary of the total program including the management philosophy and major decisions, significant test results along with major problems, and some rationale as to why some of the key events will be presented as part of this paper. Author

A88-38719#

AFTI/F-111 MISSION ADAPTIVE WING FLIGHT RESEARCH PROGRAM

KENNETH L. BONNEMA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and STEPHEN B. SMITH (USAF, Flight Test Center, Edwards AFB, OH) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 155-161. refs
(AIAA PAPER 88-2118)

The concept of a smooth variable-camber wing promises a significant improvement in performance by adapting its airfoil shape to each task required by the aircraft's mission. A joint USAF and NASA program was established to prove that significant performance improvements can be achieved with a practical wing system that varies its contour in flight as a function of pilot inputs, flight conditions, and structural loads. The flight-test program began in October 1985 and includes two phases: manual and AFCS operation. The manual-phase flight tests were completed in November 1986. After a downtime for integration and checkout of the AFCS the AFCS test phase began in August 1987. Author

A88-38721#

PROGRAM REVIEW OF EUROPEAN FIGHTER AIRCRAFT

FRANZ J. ENZINGER (Messerschmitt-Boelkow-Blohm GmbH, Manching, Federal Republic of Germany) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 171-176.
(AIAA PAPER 88-2120)

The European Fighter Aircraft (EFA) is a four-nation program (FRG, Italy, Spain, and UK) in response to the European airstaff requirement. It will be optimized for the air-to-air role. The EFA is a single-seat, twin-engine, delta-wing aircraft with a foreplane, unstable, highly maneuverable design embodying latest technology. Design emphasis is also placed on operability, reliability, maintainability, and testability as well as low mass and low signature. The engine is a new development. The radar is optimized for air-to-air and will provide a large number of operating modes and reliable operation in a high-density ECM environment. The flight test program comprises a number of prototype aircraft shared among the participating companies. Advanced flight test instrumentation and analysis methods will be used for economical and cost-effective flight testing. Author

A88-38722#

AQM-127A FULL SCALE ENGINEERING DEVELOPMENT FLIGHT TEST PROGRAM

NICHOLAS C. VANATTA and MICHAEL E. INDERHEES (Martin Marietta Corp., Electronics and Missiles Group, Orlando, FL) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 177-183.
(AIAA PAPER 88-2121)

The AQM-127A supersonic low altitude target is being developed to simulate the low altitude, sea-skimming supersonic missile threat against U.S. Navy battle groups. The mission of the AQM-127A is to provide aerial target presentations to support test, evaluation, and training exercises for antiship missile defense systems. The AQM-127A contractor flight-test program elements include the range-integration tasks, ground tests, captive flight tests, and free flight tests conducted at the Pacific Missile Test Center. The paper presents the flight-test-structure requirements and an overview of the planned objectives. It discusses the major technical issues and problems experienced in each phase and presents a summary of the corrective action taken to preserve schedule while maintaining minimum risk. Author

A88-38727#

DEVELOPMENT AND QUALIFICATION OF S-76B CATEGORY 'A' TAKEOFF PROCEDURE FEATURING VARIABLE CDP AND V2 SPEEDS

KARL W. SAAL and JEFFREY L. COLE (United Technologies Corp., Sikorsky Aircraft Div., West Palm Beach, FL) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 224-234.
(AIAA PAPER 88-2127)

An account is given of the development and qualification of a Transport Category 'A' takeoff and landing procedure for the twin-engined S-76B helicopter, which furnishes the flexibility required to encourage helicopter operators to use the Rotorcraft Flight Manual zero-exposure time takeoff and landing procedures. The takeoff procedure involves a variable critical decision-point

(CDP) and safety speed (V2), where the rejected and continued takeoff distances are directly proportional to CDP and V2 speeds, respectively; the lower CDP and V2 speeds accordingly signify shorter field lengths. A reduced gross weight/single-engine power pilot training procedure is developed. O.C.

A88-38728#
A REAL-TIME AERODYNAMIC ANALYSIS SYSTEM FOR USE IN FLIGHT
A. BERTELRUD (High Technology Corp., Hampton, VA), J. BOECK (PRC Kentron International, Hampton, VA), B. HEAPHY, and M. PARKS (Computer Sciences Corp., Hampton, VA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 235-241. refs
(AIAA PAPER 88-2128)
This paper describes a real-time analysis system used to document fuselage aerodynamic flow properties on a Boeing 737-100. The system allows the monitoring of aircraft reference parameters as well as aerodynamic data in reduced form, i.e., also boundary layer integral parameters like momentum thickness and shape factors. It also allows control of the measurement system to optimize it for different tasks, and it permits modifications to the system as the test flight proceeds. The measurements include static pressure distributions and local skin friction as well as time-averaged and turbulent boundary layer data. Author

A88-38729#
STABILITY FLIGHT TEST VERIFICATION BY MODAL SEPARATION
JAMES W. KELLY (Kelly Engineering, Los Angeles, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 242-249.
(AIAA PAPER 88-2129)
This paper describes a method of conducting flight test to verify an aircraft stability requirements. These requirements are stated in various documents for civil and military aircraft. The requirements are for the stability of the aircraft, structures, control system and pilot. The requirements are stated in terms of the geometry of the Complex Plane. A method is presented where design analysis and flight test verification are done on the Complex Plane. Author

A88-38730#
SIMULATION IN SUPPORT OF FLIGHT TEST - IN RETROSPECT
ROBERT G. HOEY IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 250-254.
(AIAA PAPER 88-2130)
A history of the use of simulation in support of flight testing is presented, concentrating on the activities at Edwards AFB and the author's personal experience with research and rocket-powered vehicles. The early use of analog computers as real time simulators is discussed as well as the transition to hybrid, and eventually, all-digital simulations. Analytical test methods, which were biproducts of simulation development such as parameter identification and accident investigations, are mentioned. The evolution of pilot interfaces and displays is described as well as some observations regarding test pilots' acceptance of simulators in the test environment. Experience with inflight simulations and motion systems is touched on briefly. Future challenges such as the rapid validation and use of flight test data in training simulators, and availability of low cost, high quality visual displays are presented. Author

A88-38731*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FLIGHT TESTING A V/STOL AIRCRAFT TO IDENTIFY A FULL-ENVELOPE AERODYNAMIC MODEL
B. DAVID MCNALLY and RALPH E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 255-267.
(AIAA PAPER 88-2134)
Flight-test techniques are being used to generate a data base for identification of a full-envelope aerodynamic model of a V/STOL fighter aircraft, the YAV-8B Harrier. The flight envelope to be modeled includes hover, transition to conventionally flight and back to hover, STOL operation, and normal cruise. Standard V/STOL operation, and normal cruise. Standard V/STOL procedures such as vertical takeoff and landings, and short takeoff and landings are used to gather data in the powered-lift flight regime. Long (3-5-min) maneuvers which include a variety of input types are used to obtain large-amplitude control and response excitations. The aircraft is under continuous radar tracking; a laser tracker is used for V/STOL operations near the ground. Tracking data are used with state-estimation techniques to check data consistency and to derive unmeasured variables, for example, angular accelerations. A propulsion model of the YAV-8B's engine and reaction control system is used to isolate aerodynamic forces and moments for model identification. Representative V/STOL flight data are presented. The processing of a typical short-takeoff and slow-landing maneuver is illustrated. Author

A88-38735#
FLIGHT TEST EXPERIENCE WITH AN RPV EMERGENCY (PARACHUTE) RECOVERY SYSTEM
K. E. FRENCH (Lockheed Missiles and Space Co., Huntsville, AL) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 299-306.
(AIAA PAPER 88-2139)
This paper describes emergency (parachute) recovery system uses and benefits experienced during engineering development and operational flight tests of the U.S. Army Aquila Remotely Piloted Vehicle (RPV). Included are brief descriptions of the Aquila RPV, the parachute subsystem, and operation of the parachute subsystem. The flight test programs are summarized with respect to total number of flights, number of RPVs used, number of crashes, and number of parachute recoveries. Postcrash and postparachute recovery repair cost data are considered in an evaluation of the relative cost effectiveness of emergency parachute recovery. It is shown that incorporation of emergency parachute recovery in the Aquila RPV system has saved the cost of approximately 16 RPVs in 550 flight tests accomplished with a total of 28 RPVs. Author

A88-38736#
THE USE OF A COMPUTER MODEL TO INVESTIGATE DESIGN COMPATIBILITY BETWEEN THE QF-4 AIRCRAFT AND THE AQM-127A
DAVID L. GOODSON and SCOTT A. BINEGAR (Martin Marietta Corp., Electronics and Missiles Group, Orlando, FL) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 307-311.
(AIAA PAPER 88-2143)
An account is given of the design requirements for the electrical power interface between AQM-127A supersonic/low altitude target drones currently under development of the U.S. Navy and the QF-4 aircraft. Attention is given to the various power load profiles likely to be encountered, and to the design and use of the computer model predicting system performance under various load configurations. The design enhancements instituted in the power interface as a result of model predictions, and the final design configuration, are also discussed. O.C.

A88-38738*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
DEVELOPMENT OF A REAL-TIME AEROPERFORMANCE ANALYSIS TECHNIQUE FOR THE X-29A ADVANCED TECHNOLOGY DEMONSTRATOR
R. J. RAY, J. W. HICKS (NASA, Flight Research Center, Edwards,

CA), and R. I. ALEXANDER (Computing Devices Co., Ottawa, Canada) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 323-337. refs
(AIAA PAPER 88-2145)

The X-29A advanced technology demonstrator has shown the practicality and advantages of the capability to compute and display, in real time, aeroperformance flight results. This capability includes the calculation of the in flight measured drag polar, lift curve, and aircraft specific excess power. From these elements, many other types of aeroperformance measurements can be computed and analyzed. The technique can be used to give an immediate postmaneuver assessment of data quality and maneuver technique, thus increasing the productivity of a flight program. A key element of this new method was the concurrent development of a real-time in flight net thrust algorithm, based on the simplified gross thrust method. This net thrust algorithm allows for the direct calculation of total aircraft drag. Author

A88-38748#
IMPACT PRESSURE ERROR ON THE EC-18B SUBSONIC AIRCRAFT
E. G. HERNANDEZ and NORMA F. TAYLOR (USAF, Flight Test Engineering Directorate, Wright-Patterson AFB, OH) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 419-423. refs
(AIAA PAPER 88-2177)

This paper presents analysis and test results of pitot-static calibration flights on the USAF EC-18B aircraft showing the development of a large impact pressure error at subsonic Mach numbers. Details include first indications of the problem, the post flight analysis performed to verify its existence, the hypothesis developed to explain the error and the methods used to confirm the hypothesis. Author

A88-38749#
STUDY OF POWERED-LIFT AIRCRAFT USING JUMP STRUTS
M. A. GAMON (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 424-434. refs
(AIAA PAPER 88-2179)

The paper presents the results of an analytical study to predict the reduction in takeoff distance that can be achieved with a jump nose gear on the NASA Quiet Short-Haul Research Aircraft (QSRA). The jump gear concept involves the release of stored energy into the landing gear, causing a rapid extension of the gear which imparts a vertical velocity to the airplane. The purpose of jump gears is to allow an earlier than normal takeoff rotation yielding a reduction in takeoff distance. Results are presented which show the degree of correlation during takeoff roll and liftoff between the analytical model and test results for the basic QSRA configuration. The takeoff distance reductions achievable with a nose jump gear on the QSRA are presented, for both compressed gas and pyrotechnic jump nose gear designs. Takeoff distance reductions on the order of 12 to 20 percent are achievable with a jump nose gear on the QSRA. Time-history responses for a typical jump nose gear takeoff are presented to illustrate the nature of the airplane dynamic response during a jump takeoff. Author

A88-38750#
FLIGHT TEST OF THE JAPANESE USB STOL EXPERIMENTAL AIRCRAFT ASKA
HIROYUKI YAMATO, NORIAKI OKADA, and TOSHIO BANDO (National Aerospace Laboratory, Chofu, Japan) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 435-447. refs
(AIAA PAPER 88-2180)

This paper describes the development and the flight test of the Japanese Upper Surface Blowing (USB) STOL experimental aircraft 'ASKA' of the Japanese National Aerospace Laboratory. The ASKA is a conversion of the Kawasaki C-1 tactical transport with four newly developed FJR710/600S turbofan engines on the wing to achieve the USB high lift system, combined with Boundary Layer Control and Stability and Control Augmentation system. Various kinds of quantitative evaluation on the performance, handling qualities and others will be made in the flight test program. Not only the flight test chiefly for the low-speed region, but also the high speed performance study in the wind tunnel, along with the Computational Fluid Dynamics application, have been made simultaneously to generate the data base for the high-speed region of the USB aircraft. Author

A88-38762*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
TECHNIQUES USED IN THE F-14 VARIABLE-SWEEP TRANSITION FLIGHT EXPERIMENT
BIANCA TRUJILLO ANDERSON, ROBERT R. MEYER, JR., and HARRY R. CHILES (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 529-548. refs
(AIAA PAPER 88-2110)

This paper discusses and evaluates the test measurement techniques used to determine the laminar-to-turbulent boundary-layer transition location in the F-14 variable-sweep transition flight experiment (VSTFE). The main objective of the VSTFE was to determine the effects of wing sweep on the laminar-to-turbulent transition location at conditions representative of transport aircraft. Four methods were used to determine the transition location: (1) a hot-film anemometer system, (2) two boundary-layer rakes, (3) surface pitot tubes, and (4) liquid crystals for flow visualization. Of the four methods, the hot-film anemometer system was the most reliable indicator of transition. Author

A88-38763#
A SURVEY OF THE FLIGHT TESTING AND EVALUATION OF CF M56 SERIES TURBOFAN
MALUR R. SHIVARAM (Hindustan Aeronautics, Ltd., Directorate of Aeronautics, Bangalore, India) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 549-557. refs
(AIAA PAPER 88-2078)

General Electric (USA) and SNECMA (France) joined together in 1974 for undertaking development of a ten ton class engine CFM56. This engine has got extensive application in various new aircraft as well as reengining of some of the old projects. The flight certification experience in clearance of this engine on various types of aircraft viz. YC-15, DC-8, Boeing 737-300, KC135R, Airbus A320/A340 etc. has left behind a unique experience which could stimulate flight test engineers and others with a purpose of making future programs more efficient, economic and complete. This experience has demonstrated the intended reduction in fuel burn rates, noise reduction, stall free operation, flame out problems and provided useful lessons for planning, acquisition and processing of flight test data. The final picture which emerges out of this review is a successful and very promising future class of engine that is revolutionary in nature. Author

A88-38800
POWER SUPPLY FOR AN EASILY RECONFIGURABLE CONNECTORLESS PASSENGER-AIRCRAFT ENTERTAINMENT SYSTEM
ARTHUR W. KELLY and WILLIAM R. OWENS (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) IN: PESC '87 - Annual IEEE Power Electronics Specialists Conference, 18th, Blacksburg, VA, June 21-26, 1987, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 650-659.

Passenger-aircraft entertainment systems have previously consisted of a single video program shown at the front of the cabin and multiple audio channels available in the armrest. A recently developed system would place small video entertainment systems at every seat for the use of each passenger. Wiring such a system with multiple connectors would cause reliability and maintenance problems and hinder timely reconfiguration of the cabin. A prototype connectorless power supply that inductively couples power to the seats across an air gap, and allows placement of seats anywhere in the cabin is reported. Both electrical and magnetic models of the connectorless power supply are developed, and measurements on the power supply are discussed. The prototype design is shown to be a practical implementation that meets all design requirements. I.E.

A88-39277
V-22 OSPREY - CHANGING THE WAY MAN FLIES
JULIAN MOXON Flight International (ISSN 0015-3710), vol. 133, May 14, 1988, p. 22-30.

With a cruise speed of 275 kt and an unrefueled range of 2100 n.mi., the U.S. Marine Corps' Osprey tilt-rotor VTOL aircraft will be capable of swift, global self-deployment. VTOL maximum gross weight will be 47,000 lb; tilting the rotors forward for short takeoff (500 ft) increases gross weight to 60,500 lb. More than 70 percent of the V-22's 12,500 lb structure is built from composite materials, so that the fuselage is made almost entirely of carbon fiber-reinforced epoxy. Power will be supplied by two cross-shafted T406-AD-400 turboshaft engines of 6000 shp output each, incorporating full-authority digital electronic control. A cut-away drawing of design details is provided. O.C.

A88-39415#
DORNIER 328 TAKING SHAPE
REINHOLD BIRRENBACH and WOLFGANG SCHMIDT Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 7-9.

A design optimization status report is made for the twin-turboprop Do 328 30-seat regional commuter airliner. CFD methods have been used with vector-processing computers to refine such aerodynamic design details as main landing gear integration, rear fuselage shape, and horizontal tail unit geometry. Extensive tests have been made of pressurized structure cycling and damage tolerance behavior. Allowances have been made in cockpit design to permit future enlargements of the avionics suite. Parts production is scheduled to begin for the Do 328 in October, 1988. Engine selection is scheduled for June, 1988. O.C.

A88-39481#
ANALYSIS OF PERFORMANCE MEASUREMENT RESULTS OF PROPELLER AIRCRAFT. I - FLIGHT PERFORMANCE [ANALIZA WYNIKOW POMIAROW OSIAGOW SAMOLOTU SMIGLOWEGO. I - OSIAGI W LOCIE]
ANDRZEJ KARDYMOWICZ Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, Jan. 1988, p. 8-10. In Polish.

A method for analyzing aircraft performance data is described. This method makes it possible to obtain the complete aircraft performance characteristics as required by current aircraft design specifications. The aircraft climbing characteristics in steady flight are considered. B.J.

A88-39504
TUPOLEV BACKFIRE
Air International (ISSN 0306-5634), vol. 34, June 1988, p. 267-275.

An account is given of information gathered to date on the configurational features, propulsion system, armaments, and performance capabilities of the Tupolev Backfire-B and -C variants; the latter, constituting about half the present force of 320 aircraft, is distinguished by new inlets with horizontal compression surfaces and a greater cross-sectional area, which may indicate the fitting of a more powerful engine than the initially employed NK-144 twin-spool low-bypass/reheated turbofan. A radius of action of over 5500 km has been inferred for subsonic high-level missions. Primary armament is the AS-4 'Kitchen' air-to-surface missile, with a variety of nuclear and conventional warheads. O.C.

A88-40530#
STRUCTURE AND EQUIPMENTS OF THE T-2 CCV AIRCRAFT
ETSUROU SENTOU, HIDETOSHI HIRATA, HIROSHI HAYAFUJI, NOBORU HATEMATA, TOSHIJI OHASHI et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 405, 1987, p. 500-510. In Japanese.

A88-40575#
ANALYSIS OF PERFORMANCE MEASUREMENT RESULTS OF AIRCRAFT. II - FLIGHT PERFORMANCE [ANALIZA WYNIKOW POMIAROW OSIAGOW SAMOLOTU SMIGLOWEGO. II - OSIAGI W LOCIE]
ANDRZEJ KARDYMOWICZ Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 43, Feb. 1988, p. 8-10. In Polish. refs

A88-40704#
FLOWFIELD STUDY AT THE PROPELLER DISKS OF A TWIN PUSHER, CANARD AIRCRAFT
NEAL J. PFEIFFER (Beech Aircraft Corp., Wichita, KS) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 19-26. refs
(AIAA PAPER 88-2511)

A developmental study was undertaken to determine the inflow for a pusher propeller installation. The effects of wing trailing edge shape and nacelle orientation were evaluated for the Beech Starship. Potential flow computer analysis was used initially to examine the problem. This analysis showed that there is a possibility of highly non-uniform flow fields occurring near pusher propellers. Potential flow analysis does not give the complete picture, however, since it neglects the effects of viscosity. These viscous effects are significant when wing and canard wakes and fuselage and nacelle boundary layers pass through or near to a propeller disk. Wind tunnel testing using a five hole pressure probe was done to map the flow field velocity at the disk location to determine the viscous effects. The experimental velocities were resolved into propeller blade fitted coordinates in order to study the periodic variation of the flow past a blade as it rotates around the disk. Author

A88-40711*# Vigyan Research Associates, Inc., Hampton, Va.
AN ANALYTICAL METHOD FOR THE DITCHING ANALYSIS OF AN AIRBORNE VEHICLE
FARHAD GHAFFARI (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 98-109. Previously announced in STAR as N88-14968. refs
(Contract NAS1-17919)
(AIAA PAPER 88-2521)

A simple analytical method has been introduced for aerohydrodynamic load analysis of an airborne configuration during water ditching. The method employs an aerodynamic panel code, based on linear potential flow theory, to simulate the flow of air and water around an aircraft configuration. The free surface separating the air and water region is represented by doublet sheet singularities. Although all the theoretical load distributions are computed for air, provisions are made to correct the pressure coefficients obtained on the configuration wetted surfaces to account for the water density. As an analytical tool, the Vortex Separation Aerodynamic (VSAERO) code is chosen to carry out the present investigation. After assessing the validity of the method, its first application is to analyze the water ditching of the Space Shuttle configuration at a 12 degree attitude. Author

A88-40868#
ANALYTICAL EVALUATION OF BIRDSTRIKE AGAINST A F-16A LAMINATED CANOPY
RICHARD A. SMITH and ROBERT E. MCCARTY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988. 11 p. refs
(AIAA PAPER 88-2268)

Computer simulations of bird impacts were carried out for four target locations along the F-16A aircraft canopy centerline. These simulations were followed by birdstrike testing at the weakest point on the canopy as determined from the first four analyses. A simulation program called MAGNA (materially and geometrically nonlinear analysis) was used. MAGNA was used to prepare finite element models of the F-16A laminated canopy and to perform eigenvalue and nonlinear dynamic analyses. The capabilities of MAGNA are described in detail. It is found that birdstrike protection increases the farther aft along the canopy centerline that impact occurs, and that canopy/HUD impingement should not cause canopy failure. K.K.

A88-41222
THE USE OF SMOOTH BENDING MOMENT MODES IN HELICOPTER ROTOR BLADE VIBRATION STUDIES
G. T. S. DONE and M. H. PATEL (City University, London, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 123, May 22, 1988, p. 71-80. refs

Difficulties in the use of prescribed deflection modes for analyzing helicopter rotor blade vibration are overcome by the adoption of a special type of assumed mode. The case of flapping and lagging motions of the rotor blade is considered. The bending moment distributions of these assumed modes are those of the normal modes of a uniform cantilever beam, and they are smoothly varying, as actually occurs on the rotor blade. Natural frequencies and normal mode shapes for a rotating helicopter rotor blade which have been evaluated using these assumed modes compare well with previous results and with those obtained using a mathematical model. R.R.

A88-41250
X-31 - THROUGH THE GRAPE BARRIER
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 43, May 1988, p. 475, 476.

The X-31 research aircraft, of which two are under construction by U.S and West German manufacturers under the sponsorship of DARPA, the West German Ministry of Defense and the U.S. Navy, is a small, single-engine delta wing/canard configuration. The most distinctive and consequential feature of the design is a set of three thrust-vectoring paddles arrayed around the exhaust of the F404 engine, furnishing all-axis thrust deflections for dynamic maneuverability in high-alpha, low speed conditions. The development and testing of efficient, reliable control laws integrating the aerodynamic control surfaces with paddle thrust vectoring is a major concern of the X-31 program. O.C.

A88-41364
SUPPRESSING DISPLAY COCKPIT REFLECTIONS
RUDOLF HARTMANN (Martin Marietta Corp., Orlando, FL) IN: Display system optics; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 45-50. refs

A 'heads-out-display' on a CRT screen may distract the crew members with whom a cockpit is shared if its light is reflected from a given crew station toward others by canopy panels, especially at night. Attention is presently given to a canopy reflection suppression system for the U.S. Army's Apache attack helicopter, which involved the placing of a linear polarizer over the CRT with its axis crossed relative to the 'skipping vector' of the reflection. This allowed the canopy panel to act as an analyzer, and resulted in a reduction of reflected luminance by a factor of 25. O.C.

N88-22022# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
MODEL SELECTION FOR THE MULTIPLE MODEL ADAPTIVE ALGORITHM FOR IN-FLIGHT SIMULATION M.S. Thesis
JAMES R. MATHES, JR. Dec. 1987 241 p
(AD-A189715; AFIT/GE/ENG/87D-40) Avail: NTIS HC A11/MF A01 CSCL 01A

This thesis extends the research accomplished by Capt Pineiro and Lt Berens in the area of adaptive algorithm implementation. Specifically, this thesis explores the performance characteristics of the multiple model estimation algorithm and how they influence the selection of aircraft models to allow the parameter adaptive control system to maintain tracking performance over a portion of the flight envelope. The aircraft dynamic equations used are those of the AFTI/F-16 and the control law design is based on the method developed by Professor Porter. After selecting a set of aircraft models that results in the best overall system response, the effect of adjusting the control law gains on the performance of the multiple model estimation algorithm is evaluated. By assuming that all states are accessible, sensor noise is then added to each of the longitudinal states to study how noise impacts model selection. A set of models that produces acceptable tracking performance over the desired flight envelope and the most immunity to sensor noise is then selected. GRA

N88-22023# Naval Postgraduate School, Monterey, Calif.
THE EFFECTS OF TORQUE RESPONSE AND TIME DELAY ON ROTORCRAFT VERTICAL AXIS HANDLING QUALITIES M.S. Thesis
PETER A. FYLES Dec. 1987 54 p
(AD-A189873) Avail: NTIS HC A04/MF A01 CSCL 01C

Research was conducted in support of updating the U.S. military handling qualities specification, MIL-H-8501A. The effects of torque response and time delay on rotorcraft vertical axis handling qualities were investigated with the use of a CH-47B variable stability helicopter and a fixed base simulator. The frequency response of displayed torque dynamics was found to be an important factor in vertical axis handling qualities. This finding has caused a revision to the update of the MIL-H-8501A. GRA

N88-22024# Lockheed-California Co., Burbank.
KRASH PARAMETRIC SENSITIVITY STUDY: TRANSPORT CATEGORY AIRPLANES Final Report, Oct. 1985 - Jun. 1986
GIL WITTLIN and W. L. LABARGE Dec. 1987 169 p
(Contract DTFA03-84-C-0004)
(AD-A189962; LR-31114; DOT/FAA/CT-87/13) Avail: NTIS HC A08/MF A01 CSCL 01C

The FAA/NASA jointly sponsored Controlled Impact Demonstration (CID) test was conducted. The CID test was a major milestone in a series of inter-related analyses and test prescribed in the FAA Crash Dynamics program. Prior to the CID test, several section and impact tests including analyses were performed. Subsequent to the CID test, correlation between KRASH pretest analyses and actual test data was evaluated. The actual CID test resulted in an unsymmetrical impact which was modeled and the results compared with the recorded test data. Analyses are performed for air-to-ground, ground-to-ground, and longitudinal-only impacts. The results are presented in the form of triangular pulses with definition of the peak amplitude, base time duration and pulse change of velocity. The analytically obtained data are integrated with the full-scale aircraft and section test data to formulate crash design velocity envelopes. The results of the study are used to suggest seat dynamic test conditions. GRA

N88-22025# Boeing Military Airplane Development, Seattle, Wash.
DEVELOPMENT AND EVALUATION OF AN AIRPLANE FUEL TANK ULLAGE COMPOSITION MODEL. VOLUME 2: EXPERIMENTAL DETERMINATION OF AIRPLANE FUEL TANK ULLAGE COMPOSITIONS Final Report, Nov. 1985 - Dec. 1986
A. J. ROTH Oct. 1987 118 p
(Contract F33615-84-C-2431)
(AD-A190408; D180-30344-2-VOL-2; AFWAL-TR-87-2060-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 21D

The development and evaluation of a computer model designed to predict the composition of airplane fuel tank ullage spaces is documented in two volumes. Volume 1, Airplane Fuel Tank Ullage Computer Model: A detailed mathematical description of the model as it relates to the physical processes governing the ullage of an airplane fuel tank is included, along with user instructions and examples. Extensive comparisons of computer model predictions to experimental data are included. The model is interactive and can be used on a variety of computers including personal

computers. Volume 2, Experimental Determination of Airplane Fuel Tank Ullage Compositions: Experimental work conducted using a fuel tank simulator to investigate the composition of airplane fuel tank ullage spaces is described. The investigations include ullage mixing by diffusion and convection, oxygen evolution during simulated climbs and refueling and complete mission simulations.
GRA

N88-22029# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
PRELIMINARY AIRWORTHINESS EVALUATION OF THE UH-60A EQUIPPED WITH THE XM-139 VOLCANO MINE DISPENSING SYSTEM Final Report
THOMAS L. REYNOLDS, JOHN I. NAGATA, RANDALL W. CASON, and DAUMANTS BELTE Aug. 1987 125 p
(AD-A190604) Avail: NTIS HC A06/MF A01 CSCL 15F

Preliminary airworthiness flight tests totalling 22.4 hr were conducted at West Palm Beach, Fla., (elevation 28 feet). The tests were conducted to determine handling qualities and performance of the UH-60A in the VOLCANO system configuration at an average mission gross weight of 20,500 pounds and a longitudinal center of gravity at fuselage station 351.0. The handling qualities of the UH-60A with the VOLCANO system installed were similar to the normal utility UH-60A. Three shortcomings were noted in this configuration: (1) the increased frequency and magnitude of tail shake with the VOLCANO installed; (2) the position error for the ship's airspeed system was increased by approximately 8 knots at higher speeds (120 KCAS) due to the installation of the VOLCANO mine dispensing system; and (3) Stability Augmentation System (SAS) OFF dynamic response, not attributed to the VOLCANO installation, was aperiodic and divergent. The UH-60A helicopter with VOLCANO failed to meet two requirements of the Prime Item Development Specification; however, these noncompliances were not significant. Recommendations were made to incorporate data into the applicable portion of the VOLCANO operator's manual and to conduct additional testing.
GRA

N88-22030# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
PRELIMINARY AIRWORTHINESS EVALUATION OF THE UH-60A WITH ADVANCED DIGITAL OPTICAL CONTROL SYSTEM (ADOCS) Final Report
GARY L. BENDER and ROBERT D. ROBBINS Aug. 1987 57 p
(AD-A190674) Avail: NTIS HC A04/MF A01 CSCL 01D

The (ADOCS) is being developed on a UH-60A helicopter by the Boeing Vertol Co. to demonstrate the feasibility of a digital optical control system. The U.S. Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation of ADOCS installed on a UH-60A aircraft to evaluate the handling qualities and to provide data for issuance of an airworthiness release for a demonstration of the system to the Army aviation community through a guest pilot program. The ADOCS consists of a Primary Flight Control System, which incorporates limited-displacement side-arm controllers for pilot inputs (right-side pilot station only), and an Automatic Flight Control System (AFCS) which is used to augment the basic UH-60A stability. Displacement of the controllers is measured and transmitted optically to digital flight control processors where the control commands are summed with the AFCS commands and sent to the rotor control actuators. The evaluation was conducted at the BV Flight Test Center at Wilmington, Delaware between 25 March and 9 April, 1987 and consisted of 9 flights comprising 17.5 hours (14.9 productive hours). Tests included handling qualities, simulated system failures, and mission maneuvers. Three enhancing characteristics were found: (1) the ease in rolling to and maintaining a desired bank angle; (2) the capability to maintain hands-off stabilized hover with all selectable modes engaged, and; (3) the capability of the barometric altitude hold mode to maintain altitude during simulated instrument flight tasks.
GRA

N88-22031*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SHAPE SENSITIVITY ANALYSIS OF WING STATIC AEROELASTIC CHARACTERISTICS
JEAN-FRANCOIS M. BARTHELEMY and FRED D. BERGEN (Virginia Polytechnic Inst. and State Univ., Blacksburg.) May 1988 30 p
(NASA-TP-2808; L-16418; NAS 1.60:2808) Avail: NTIS HC A03/MF A01 CSCL 01C

A method is presented to calculate analytically the sensitivity derivatives of wing static aeroelastic characteristics with respect to wing shape parameters. The wing aerodynamic response under fixed total load is predicted with Weissinger's L-method; its structural response is obtained with Giles' equivalent plate method. The characteristics of interest include the spanwise distribution of lift, trim angle of attack, rolling and pitching moments, wind induced drag, as well as the divergence dynamic pressure. The shape parameters considered are the wing area, aspect ratio, taper ratio, sweep angle, and tip twist angle. Results of sensitivity studies indicate that: (1) approximations based on analytical sensitivity derivatives can be used over wide ranges of variations of the shape parameters considered, and (2) the analytical calculation of sensitivity derivatives is significantly less expensive than the conventional finite-difference alternative. Author

N88-22032# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
IN-SERVICE MEASUREMENTS OF SAAB SF-340 LANDING GEAR LOADS
ANDERS I. GUSTAVSSON Oct. 1987 106 p
(Contract STU-84-4563)
(FFA-TN-1987-48; ETN-88-92199) Avail: NTIS HC A06/MF A01

Landing gear loads on a commuter airliner were continuously monitored for 6 months, including different load components, load cases, runway and weather conditions, and different pilots and ground personnel. The data are presented as cumulative excedances of longitudinal, transversal, and vertical loads obtained from the rainflow count analyses performed on-line during the measurements. It is emphasized that the nose gear is more severely strained in terms of ground reaction factors than the main gears.
ESA

N88-22033*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
EFFECTS OF UPDATE AND REFRESH RATES ON FLIGHT SIMULATION VISUAL DISPLAYS
GARY V. KELLOGG and CHARLES A. WAGNER May 1988 19 p
(NASA-TM-100415; H-1439; NAS 1.15:100415) Avail: NTIS HC A03/MF A01 CSCL 01C

An experiment was performed to study the effects of update and refresh rates on dynamic calligraphic CRT displays, particularly those used for visual displays in flight simulators. A moving horizontal line was generated on a CRT and observed at various velocities. Observations were made with both one and two refreshes per update. The data gathered from these observations are presented on plots of refresh-update rate as a function of display velocity. The display velocity where picture degradation occurs can be found by using these plots. These velocities are related to actual simulated aircraft angular and linear velocities. Results show that a visual display updated at 30 Hz and refreshed at 60 Hz degrades at very low simulated aircraft angular and linear velocities. These velocities at which degradation occurs can be significantly increased by increasing the update rate of the visual display. Only minor improvements are possible by refreshing the display twice for each uptake. To display rapidly changing flight scenery without degradation, the display update rate must be far in excess of 60 Hz, typically several hundred Hz. Author

N88-22245# Joint Publications Research Service, Arlington, Va.
INFLUENCE OF UNSTEADY AERODYNAMIC FORCES ON DYNAMIC RESPONSE OF VARIABLE SWEEP AIRCRAFT Abstract Only

MING YAN and CHUANREN QIU *In its* JPRS Report: Science and Technology. China p 62 11 Dec. 1987 Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, Peoples Republic of China), v. 5, no. 3, Sep. 1987 p 261-270 Original language document was announced in IAA as A88-14018
Avail: NTIS HC A06/MF A01

A numerical method to obtain a complete solution for the dynamic response of a variable sweep wing aircraft while changing the angle of sweep is presented. Both aerodynamic and trajectory computations are included. During the flight of the sweptback angle variation, the aerodynamic forces acting on the aircraft are obviously unsteady, therefore, methods for computing these forces and accompanying responses of aircraft are also presented. Author

N88-22887# National Aerospace Lab., Amsterdam (Netherlands).
DEVELOPMENT OF A FLEXIBLE AND ECONOMIC HELICOPTER ENGINE MONITORING SYSTEM
A. A. TENHAVE and C. R. TJALSMA 23 Jul. 1986 16 p Presented at the 12th European Rotocraft Forum, Garmisch-Partenkirchen, Fed. Republic of Germany, 22-25 Sep. 1986
(PB88-165147; NLR-MP-86046-U) Avail: NTIS HC A03/MF A01 CSCL 01C

In terms of fatigue life consumption the Royal Netherlands Navy (RNLN) is by now one of the leading operators of the Westland Lynx helicopter. Consequently, the RNLN feels a growing need to gain more insight into the Lynx fatigue loading environment. The topic of Lynx engine loading is the subject of a RNLN funded NLR research program aimed at investigating the possibility of continuous and automated monitoring of engine fatigue damage accumulation based on the Rolls-Royce Cyclic Lide Control concept. A pilot flight test program was performed, the results of which are being used for the development of a usable Lynx engine inflight data processor. Such a device will provide valuable information on the RLNL Lynx engine service loading and may be the basis of computerized Cyclic Life Control within the RNLN in the future. The major topics of the program are generally described. GRA

N88-22888# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
DESIGN STUDIES OF PRIMARY AIRCRAFT STRUCTURES IN ARALL LAMINATES
J. W. GUNNINK Jun. 1987 32 p Presented at the ICCM 6/ECCM 2 Meeting, London, United Kingdom, 20-24 Jul. 1987
(LR-520; B8733286; ETN-88-92463) Avail: NTIS HC A03/MF A01

Use of ARALL for fatigue dominated structural parts, like the lower wing and the pressure cabin of an aircraft, was assessed. To investigate the potential of the material, preliminary design studies were carried out on these components. The studies result in a weight reduction of more than 25 percent for the lower wing and the pressure cabin. ESA

N88-22889# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
THE INITIAL CALCULATION OF RANGE AND MISSION FUEL DURING CONCEPTUAL DESIGN
E. TORENBEEK Aug. 1987 27 p
(LR-525; B8733276; ETN-88-92466) Avail: NTIS HC A03/MF A01

Derivations for the range of aircraft with gas turbine propulsion systems, which cannot be characterized to have either constant specific fuel consumption or constant propulsion efficiency are presented. The effects of different cruise techniques are investigated. It is found that for preliminary design purposes a very simple approximation of the fuel fraction can be used for all aircraft categories and various cruise techniques. This result was used to compute the total mission and reserve fuel. A method to derive the range parameter, eta L/D, for existing aircraft from their payload vs. range diagram is proposed. Such statistical data of the range parameter may be used as input for the calculation of the fuel fraction. The method is intended for use during conceptual design studies for a first estimation of the takeoff weight. ESA

N88-22890# European Space Agency, Paris (France).
DIGITAL PROCESSING OF FLIGHT DATA OF A HELICOPTER WITHOUT USING ANTI-ALIASING FILTERS
RAINER HOLLAND (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany) Mar. 1988 57 p Transl. into ENGLISH of Digitale Verarbeitung von Flugversuchsdaten ohne Verwendung von Anti-Aliasing-Filtern am Beispiel eines Hubschraubers (Brunswick, Fed. Republic of Germany, DFVLR), Jun. 1987 54 p Original language document was announced as N88-14981
(ESA-TT-1094; DFVLR-MITT-87-12; ETN-88-92562) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 22.50 DM

The possibility of sampling helicopter flight test data directly without prior artificial band limiting was studied. Data are filtered in the digital computer, after sampling. The results are compared with the measurement data obtained from analog filters before sampling. The decisive advantage of digital filtering is apparent. This occurs as a program in a computer where the frequency characteristics can be rapidly changed by changing numerical values. Analog filters require an elaborate technical implementation and space for the mechanical construction. A smaller and more compact measuring system could be achieved if anti-aliasing filters are not used. The recording of unfiltered measurement values provides additional information on possible signal distortion. The frequency characteristics of the digital filter can be varied within defined limits (aliasing) after the flight test. The greater data quantity in the case of the unfiltered sampling is a disadvantage which, however, is no longer significant with the use of larger storage media. However, the high computing time can be a disadvantage if use under real-time conditions is necessary. ESA

N88-22891*# Van der Velden (Alexander J. M.), Berkeley, Calif.
CONCEPTUAL FINAL PAPER ON THE PRELIMINARY DESIGN OF AN OBLIQUE FLYING WING SST Final Report
ALEXANDER J. M. VANDERVELDEN 6 Dec. 1987 33 p
(Contract NAG2-471)
(NASA-CR-182879; NAS 1.26:182879) Avail: NTIS HC A03/MF A01 CSCL 01C

A conceptual Oblique Flying Wing Supersonic Transport Aircraft (OFW, or surfplane because of its shape) was first proposed in 1957. It was reintroduced in 1987 in view of the emerging technology of artificial stabilization. This paper is based on the performance and economics study of an M2 B747-100B replacement aircraft. In order to make a fair comparison of this configuration with the B747, an end-sixties structural technology level is assumed. It is shown that a modern stability and control system can balance the aircraft and smooth out gusts, and that the OFW configuration equals or outperforms the B747 in speed, economy and comfort. Author

N88-22892*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MINIMUM WEIGHT DESIGN OF ROTORCRAFT BLADES WITH MULTIPLE FREQUENCY AND STRESS CONSTRAINTS
ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, Va.) and JOANNE L. WALSH Mar. 1988 15 p Presented at the AIAA/ASME/ASCE/AHS 29th Structures, Structural Dynamics and Materials Conference, Williamsburg, Va., 18-20 Apr. 1988
(NASA-TM-100569; NAS 1.15:100569) Avail: NTIS HC A03/MF A01 CSCL 01C

Minimum weight designs of helicopter rotor blades with constraints on multiple coupled flap-lag natural frequencies are studied. Constraints are imposed on the minimum value of the blade autorotational inertia to ensure sufficient rotary inertia to autorotate in case of engine failure and on stresses to guard against structural failure due to blade centrifugal forces. Design variables include blade taper ratio, dimensions of the box beam located inside the airfoil and magnitudes of nonstructural weights. The program CAMRAD is used for the blade modal analysis; the program CONMIN is used for the optimization. A linear approximation involving Taylor series expansion is used to reduce the analysis effort. The procedure contains a sensitivity analysis consisting of analytical derivatives for objective function and constraints on autorotational inertia and stresses. Central finite difference derivatives are used for frequency constraints. Optimal designs are obtained for both rectangular and tapered blades. Using this method, it is possible to design a rotor blade with reduced weight, when compared to a baseline blade, while satisfying all the imposed design requirements. Author

N88-22893*# General Dynamics Corp., Fort Worth, Tex.
PARAMETRIC STUDY OF SUPERSONIC STOVL FLIGHT CHARACTERISTICS
DAVID C. RAPP Mar. 1985 245 p
(Contract NAS2-11753)
(NASA-CR-177330; NAS 1.26:177330) Avail: NTIS HC A11/MF A01 CSCL 01C

A number of different control devices and techniques are evaluated to determine their suitability for increasing the short takeoff performance of a supersonic short-takeoff/vertical landing (STOVL) aircraft. Analysis was based on a rigid-body mathematical model of the General Dynamics E-7, a single engine configuration that utilizes ejectors and thrust deflection for propulsive lift. Alternatives investigated include increased static pitch, the addition of a close-coupled canard, use of boundary layer control to increase the takeoff lift coefficient, and the addition of a vectorable aft fan air nozzle. Other performance studies included the impact of individual E-7 features, the sensitivity to ejector performance, the effect of removing the afterburners, and a determination of optional takeoff and landing transition methods. The results pertain to both the E-7 and other configurations. Several alternatives were not as well suited to the E-7 characteristics as they would be to an alternative configuration, and vice versa. A large amount of supporting data for each analysis is included. Author

N88-22894# National Aeronautical Establishment, Ottawa (Ontario).
THE APPLICATION OF LINEAR MAXIMUM LIKELIHOOD ESTIMATION OF AERODYNAMIC DERIVATIVES FOR THE BELL-205 AND BELL-206
J. H. DELEEUW and K. HUI Oct. 1987 60 p
(AD-A191279; NAE-AN-48; NRC-28442) Avail: NTIS HC A04/MF A01 CSCL 01A

Parameter identification from flight test data of fixed-wing aircraft is currently a common procedure for application to aircraft development work, validation of simulation, flight simulator verification, flight control systems synthesis, aircraft handling qualities, flight envelope expansion and airplane certification. Similar work on the identification of the more complex helicopter system is currently still in the research stage. This report describes a number of flight test experiments involving the application of parameter estimation techniques to helicopters in order to determine the stability and control derivatives and to obtain information to identify improvements in the structure of the helicopter model. GRA

N88-22895# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
AIRWORTHINESS AND FLIGHT CHARACTERISTICS TEST OF A SKI ASSEMBLY FOR THE UH-60A BLACK HAWK HELICOPTER Final Report, for 30 Apr. 1987
RANDALL W. CASON, JOHN I. NAGATA, THOMAS L. REYNOLDS, and DAUMANTS BELTE Aug. 1987 127 p
(AD-A191414) Avail: NTIS HC A07/MF A01 CSCL 01C

An Airworthiness and Flight Characteristics test of the UH-60A helicopter (S/N 84-23953) configured with a ski assembly was conducted by the U.S. Army Aviation Engineering Flight Activity. The test was conducted at the Sikorsky Flight Test Facility at West Palm Beach, Florida (elevation 28 feet). A total of 25.5 productive flight hours were flown during the period 6 to 30 April, 1987. Tests were conducted to determine the handling qualities and performance decrement of the ski assembly on the UH-60A helicopter at average mission gross weights of approximately 16,000 and 22,000 pounds. The handling qualities of the UH-60A with the ski assembly installed were essentially unchanged from those previously reported for the normal utility UH-60A. Two previously reported shortcomings are still evident: neutral static longitudinal stability during intermediate rated power climbs, and self-excited aircraft pitch oscillation with the collective control raised sufficiently for the aircraft to be light on its wheels. The equivalent flat plate area of the ski assembly was determined to be three sq ft. GRA

N88-23031# Joint Publications Research Service, Arlington, Va.
AIRCRAFT FLIGHT DYNAMICS RESEARCH IN PAST DECADE REVIEWED
LIQIN FAN and QISHUN CHEN *In its* JPRS Report: Science and Technology. China p 1-8 3 May 1988 Transl. into ENGLISH from Guoji Hangkong (Beijing, People's Republic of China), no. 2, Feb. 1988 p 28-31
Avail: NTIS HC A08/MF A01

Chinese research over the past decade in flight dynamics is reviewed. Areas discussed include research in aircraft flight quality specifications and flight performance specifications, controllable flight dynamics, atmospheric disturbance, study of non-linear characteristics, and development of test research methods. J.P.B.

N88-23129# Tracor Hydronautics, Inc., Laurel, Md.
AN EXPERIMENTAL STUDY TO DETERMINE THE FLOW AND THE SUBSONIC STATIC AND DYNAMIC STABILITY CHARACTERISTICS OF AIRCRAFT OPERATING AT HIGH ANGLES-OF-ATTACK
ALEX GOODMAN and CLINTON E. BROWN *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 28 p Jun. 1987
Avail: NTIS HC A20/MF A01

A comprehensive series of experiments was conducted in the Tracor Hydronautics Ship Model Basin (HSMB) to determine the subsonic static and dynamic stability characteristics of a 3.5-foot span, 60-deg delta-high-wing fuselage model operating at high angles-of-attack up to 68 deg. In addition, typical results of flow visualization studies for a range of Reynolds numbers from 0.2 to 1.6 x 10 to the 6th, are presented. Also, the motions, force and moment coefficients resulting from a simulated pitchup maneuver are presented. Described is the HSMB Large Amplitude Horizontal Planar Motion Mechanism System (LAHPMM), 60-deg delta-wing-fuselage model, model-support systems, and the data acquisition and processing system used. The advantages of performing tests in the HSMB using the LAHPMM technique over existing wind tunnel techniques, such as curved flow and combined oscillation, for determination of the dynamic stability derivatives are presented and discussed. Results compare favorably with earlier (1950) tests of a similar configuration at angles of attack up to 32 deg. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-38707*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
FORMULATON OF A GENERAL TECHNIQUE FOR PREDICTING PNEUMATIC ATTENUATION ERRORS IN AIRBORNE PRESSURE SENSING DEVICES
STEPHEN A. WHITMORE (NASA, Flight Research Center,

Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 40-50. refs
(AIAA PAPER 88-2085)

Presented is a mathematical model, derived from the Navier-Stokes equations of momentum and continuity, which may be accurately used to predict the behavior of conventionally mounted pneumatic sensing systems subject to arbitrary pressure inputs. Numerical techniques for solving the general model are developed. Both step and frequency response lab tests were performed. These data are compared against solutions of the mathematical model. The comparisons show excellent agreement. The procedures used to obtain the lab data are described. In-flight step and frequency response data were obtained. Comparisons with numerical solutions of the mathematical model show good agreement. Procedures used to obtain the flight data are described. Difficulties encountered with obtaining the flight data are discussed. Author

A88-38715#
METEOPOD, AN AIRBORNE SYSTEM FOR MEASUREMENTS OF MEAN WIND, TURBULENCE, AND OTHER METEOROLOGICAL PARAMETERS
P. VOERSMANN and A. M. HOFF (Aerodata Flugmesstechnik GmbH, Brunswick, Federal Republic of Germany) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 127-132.
(AIAA PAPER 88-2103)

An aircraft and helicopter pod construction is presented which contains the aerological sensor hardware for on-board measurements of wind and turbulence. The brief description of the principle of airborne wind determination shows the inherent necessity of precise navigation data in combination with aerological parameters. The METEOPOD system is a compact solution to present the meteorological background to all scientific aircraft users who are concerned with geophysical data being influenced by the atmosphere. Nearly every aircraft including helicopters is suitable for the operation of the pod. The mean and turbulent transport processes can be calculated on-line. Author

A88-38766#
KEYS TO A SUCCESSFUL FLIGHT TEST
JUDIE FECHTER and CHARLENE MILLS (IBM, Systems Integration Div., Owego, NY) AIAA, Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988. 17 p. refs
(AIAA PAPER 88-2174)

An account is given of those test methods and tools that have evolved through flight test experience oriented toward avionics integration in the cases of the U.S. Navy's LAMPS SH-60 Seahawk helicopter, the U.S. Army's HH-60 Nighthawk helicopter, and the MC-130H Combat Talon II aircraft flight test programs. Attention is given to ways of managing different types of test requirements, joint contractor/customer flight test planning and testing responsibilities, the optimum flight test organization, flight card generation, flight test configuration management, and software tools. O.C.

A88-39495#
TAXIWAY SAFETY USING MODE S SSR [ROLLFELDSICHERUNG AUF DER BASIS VON SSR MODE S]
WOLFGANG DETLEFSEN (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), vol. 29, no. 1, 1988, p. 126-133. In German. refs

The feasibility of using the mode S SSR transponders being installed on transport aircraft to monitor taxiway traffic is investigated. The operational principles of mode S, its advantages over mode A/C, and time-of-flight and triangulation methods for taxiway position determination using the mode S transponder signal are discussed in detail and illustrated with extensive diagrams. The potential problems presented by multipath propagation and the need to differentiate landed and flying aircraft are considered. The components of a complete taxiway monitoring system include mode S SSR for aircraft, follow-me cars, and emergency vehicles; a radio direction-finding system for other vehicles, a taxiway surveillance radar with digital image processing to detect obstacles, and provision for communicating warnings and taxiway traffic information to the pilot (probably using the data-link functions of mode S SSR). T.K.

A88-39496#
A MILLIMETER-WAVE LOW-RANGE RADAR ALTIMETER FOR HELICOPTER APPLICATIONS - EXPERIMENTAL RESULTS
M. LANGE, J. DETLEFSEN, M. BOCKMAIR, and U. TRAMPNAU (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), vol. 29, no. 1, 1988, p. 138-148.

The design and performance of a high-resolution 35-GHz FM-CW radar altimeter for use in helicopters maneuvering at very low altitudes (e.g., in unpowered emergency landing exercises) are reported. Digital beat-signal processing and spectral analysis are employed to decrease system vulnerability to multitarget situations. The results of experimental trials are presented in extensive graphs and discussed in detail, and it is shown that the altimeter responds to treetops, giving a clear indication of obstacle-free regions below the helicopter. System accuracy is given as + or - 0.1 m at altitude 0-20 m and + or - 1 m at altitude 20-150 m. T.K.

A88-40517
REFLECTIONS ON THE INTEGRATION OF AVIONICS EQUIPMENT [REFLEXIONS SUR L'INTEGRATION DES EQUIPEMENTS D'AVIONIQUE]
A. JANEX and J.-C. JOGUET (LMT Radio Professionnelle, Boulogne-Billancourt, France) (Instituts de Navigation, Congres International, Sydney, Australia, Feb. 2-5, 1988) Navigation (Paris) (ISSN 0028-1530), vol. 36, April 1988, p. 180-187. In French.

The integration of various airborne systems is considered. Current integration concepts involve the regrouping of previously separate functions into larger systems such as flight control systems, weapon management systems, and communications, navigation, identification (CNI) systems. CNI systems include UHF communications, TACAN/DME, and IFF. TDMA systems for the integration of CNI functions are also considered. The Pave Pillar system for integrating fighter aircraft avionics includes Integrated Communication, Navigation and Identification Avionics. Other concepts, such as the integration of the INS, GPS, ILS, MLS, VOR, and TACAN navigation systems, and the integration of the V/UHF, JTIDS, and HF communications systems, are considered. R.R.

A88-40518
NAVIGATION AND PERFORMANCE COMPUTER [CALCULATEUR DE NAVIGATION ET DE PERFORMANCE]
PAUL CAMUS (Airbus Industrie, Blagnac, France) (Instituts de Navigation, Congres International, Sydney, Australia, Feb. 2-5, 1988) Navigation (Paris) (ISSN 0028-1530), vol. 36, April 1988, p. 188-195. In French.

Aircraft navigation and cockpit data display are reviewed, with emphasis on the Airbus inertial guidance system. The Airbus performance and navigation computer determines the optimum velocity and latitude for each mission and facilitates navigation guidance in four dimensions (the fourth dimension being time), taking traffic constraints into account. Calculations are performed in real time and involve the use of mathematical models for performance optimization, in addition to data on the infrastructure of air routes. Airbus CRT displays include a virtual geographic map showing the route followed, the aircraft velocity, the force and direction of the wind, and the names of points flown over. R.R.

A88-40534#
TRENDS AND PROBLEMS OF HEAD-UP DISPLAY
ISAO IWASAKI Japan Society for Aeronautical and Space

Sciences, Journal (ISSN 0021-4663), vol. 36, no. 408, 1988, p. 30-35. In Japanese. refs

A88-41096
THE EFFECT OF AIRCRAFT ANGULAR VIBRATIONS ON THE QUALITY OF REMOTELY SENSED IMAGES [DIE WIRKUNG ANGULARER LUFTFAHRZEUGSCHWINGUNGEN AUF DIE BILDDATEN VON FERNERKUNDUNGSSYSTEMEN]
FRANZ PLISCHKE (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 2, 1988, p. 43-47. In German. refs

Aircraft rotational vibration and its effects on the performance of optical and electronic remote-sensing equipment are investigated analytically and experimentally. Expressions describing the rotation about the three aircraft axes are derived and discussed. In the flight tests, photogrammetric cameras and multispectral cameras, whiskbroom and pushbroom scanners, and radars were flown on An-2, L-410 UVP, IL-18, and Mi-8 aircraft under pilot, autopilot, or combined autopilot-pilot control and under different turbulence conditions. A specially developed 1-kg gyroscopic device is used to measure the angular motion in all three axes, both in the aircraft and on the sensor. The results are presented in tables and graphs and shown to be in good general agreement with the theoretical computations. Motion about the longitudinal axis is found to be the dominant cause of image-quality degradation. T.K.

A88-41098
AVIONICS FOR TRANSPORT AIRCRAFT - CURRENT DEVELOPMENT STATUS [AUSRUESTUNG VON VERKEHRSFLUGZEUGEN - STAND DER ENTWICKLUNG]
GUSTAV WESTPHAL (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, German Democratic Republic) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 24, no. 2, 1988, p. 76-80. In German.

The technology and capabilities of present and next-generation avionics for transport aircraft are reviewed. Systems for status monitoring, flight control, navigation, communication, flight safety, and special missions are considered, and particular attention is given to computer integration of different onboard systems, the display of systems information in the cockpit, new demands on ATC and the technologies being developed to meet them, the application of satellite-based navigation and emergency position-finding systems, and the maintenance and repair problems posed by the introduction of advanced avionics. Block diagrams and drawings of cockpit displays are provided. T.K.

A88-41361
DISPLAY SYSTEM OPTICS; PROCEEDINGS OF THE MEETING, ORLANDO, FL, MAY 21, 22, 1987
ARTHUR COX, ED. (KFO Associates, Inc., Wyckoff, NJ) and RUDOLF HARTMANN, ED. (Martin Marietta Corp., Orlando, FL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 778), 1987, 103 p. For individual items see A88-41362 to A88-41369.
(SPIE-778)

The present conference on human vision, image displays, and helmet-mounted displays gives attention to brain organization for visual tasks, the validation of visual cues in flight simulator displays, an eye-tracking joystick, the effects of task training and instructions on visual load, aerial image systems, the suppression of display cockpit reflections, and cockpit readiness for night vision goggles. Also discussed are circular polarization image selection for 'timeplex' stereoscopic video displays, optical design criteria for binocular helmet-mounted displays, the development of a wide-FOV helmet-mounted display for simulators, an integrated approach to helmet display system design, and an innovative, lightweight helmet airborne display and target sight. O.C.

A88-41366
OPTICAL DESIGN CRITERIA FOR BINOCULAR HELMET-MOUNTED DISPLAYS
MARTIN SHENKER (Farrand Optical Co., Inc., Valhalla, NY) IN: Display system optics; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 70-78.

Binocular helmet-mounted displays have become increasingly popular over the past several years; particular emphasis has been placed on achieving wide field of view displays with resolution capability greater than that attainable with a monocular system utilizing a single CRT. Binocular display systems with severely divergent axes have been developed wherein the horizontal field is divided into three areas, that visible to the right eye only, that visible to the left eye, and an overlap region. A typical system has individual displays with 80-deg fields-of-view with axes turned outward + or - 20 deg achieving a total field of 120 deg with a 40-deg overlap. The turnout of the optical axes means that the center of the display field is 20 deg off-axis in the individual displays. Almost all points in the overlap regions are at significantly different off-axis angles in the two displays. The implications of these factors relative to required aberrational correction and system characteristics are discussed. Author

A88-41367
DEVELOPING A WIDE FIELD OF VIEW HMD FOR SIMULATORS
BILL MCLEAN and STEVE SMITH (Hamilton Standard, Farmington, CT) IN: Display system optics; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 79-82. refs

An evaluation is made of the design lessons learned during the development of a wide-FOV helmet-mounted display (HMD) by personnel whose expertise ranged over the fields of optics, electronics, mechanical design, video display design, human vision, and composite materials. The HMD's image was produced by two matched high-resolution video cameras fitted with minimum-distortion camera lenses; the device itself was intended to support flight simulation studies for advanced rotary wing applications. In order to increase the horizontal FOV to 120 deg, the right and left images of 80 deg each are overlapped by 40 deg. O.C.

A88-41368
AN INTEGRATED APPROACH TO HELMET DISPLAY SYSTEM DESIGN
JAMES E. MELZER and ERIC W. LARKIN (Kaiser Electronics, Optical and Helmet Systems Dept., San Jose, CA) IN: Display system optics; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 83-88.

The retrofitting of a display apparatus to an existing helmet in order to configure a helmet-mounted display (HMD) has led to shortcommings in system weight, center-of-gravity, vision obstructions, and head-motion restriction. The present HMD design approach has set out from the development of an optical system having the desired performance characteristics, folding it in a way that conforms to the human head's contours, and then designing the helmet around the optics. The resulting HMD compromises neither helmet life-support functions nor optical system operations. O.C.

A88-41369
A LIGHTWEIGHT INNOVATIVE HELMET AIRBORNE DISPLAY AND SIGHT (HADAS)
DANIEL NAOR, ODED ARNON, and ARIE AVNUR (ELOP Electrooptics Industries, Ltd., Defense Systems Div., Rehovot, Israel) IN: Display system optics; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 89-95.

The fighter aircraft pilot Helmet Airborne Display And Sight (HADAS) system combines holographic optical elements and fiber-optics display functions with real-time image processing of helmet location to provide 'all-aspect' HUD performance. In effect, helmet-mounted display and helmet-mounted sight systems are integrated in a single apparatus. Attention is presently given to the complex tradeoff and integration tasks faced by the developers of HADAS in their multidisciplinary research efforts, as well as to the laboratory verification test data obtained for the system to date. O.C.

N88-22896# National Aerospace Lab., Tokyo (Japan).
FIRST FLIGHT SIMULATOR TEST OF THE HEAD-UP DISPLAY FOR NAL QSTOL EXPERIMENTAL AIRCRAFT (ASUKA)
KEIJI TANAKA, KENJI YAZAWA, and TOSHIHARU INAGAKI Oct. 1986 36 p In JAPANESE; ENGLISH summary
(DE88-751804; NAL-TM-554) Avail: NTIS (US Sales Only) HC A03

The following evaluation and information were obtained after the approach and landing simulation of Head-up Display HUD: (1) Velocity-Vector (VV) mode: effective for actual landing; easily controllable; landing accuracy is improved, (2) Pseudo-landing mode: effective for actual landing, but visibility of an actual runway deteriorates when the mock runway and the actual one overlap; pseudo-flare and touchdown are not exact; concerning pseudo-landing in the air, effective landing becomes possible, (3) CTOL landing: since the cross-checking load is alleviated and the flight path is accurately controlled, accurate approach becomes possible; Trim vector is effective for controlling speed and attitude and anticipatory control of power becomes feasible through speed vector, (4) STOL landing: when the stability control augmentation system (SCAS) is off, difficulty of lateral control is induced and control load is enhanced. DOE

N88-22897# National Aerospace Lab., Tokyo (Japan).
BASIC DESIGN OF A FLIGHT DIRECTOR SYSTEM FOR NAL STOL RESEARCH AIRCRAFT
KEIJI TANAKA Dec. 1986 26 p In JAPANESE; ENGLISH summary
(DE88-751806; NAL-TM-558) Avail: NTIS (US Sales Only) HC A03

A basic design concept of a flight director system (FDS) is developed in an effort to examine backside operations during the approach phase, centering on the transient responses at the time of the shift to the ILS step and the stability during the following steps. This FDS has three commands: pitch command, flight path command, and bank command. Equations are formulated to generate these commands. To determine the flight-director dynamics, models of pilots, FDS and STOL research aircraft are developed on the assumption that they can be connected linearly, and dynamic responses of the entire system are calculated. To set up parameters based on responses of the system, examination is made of a stabilization/control system model, pilot model for pitch control, wash-out time constant of the pitch command loop, pilot model for speed control, glide slope capture characteristics, localizer deviation correction characteristics, and localizer capture characteristics. DOE

N88-22898# Aeritalia S.p.A., Turin (Italy). Gruppo Sistemi Avionics ed Equipaggiamenti.
RAPID PROTOTYPING OF COMPLEX AVIONICS SYSTEM ARCHITECTURES
L. BERARDI, N. GIORGI, W. MELLANO, A. VALANTE, and E. ZUCCO 1987 12 p
(ETN-88-92275) Avail: NTIS HC A03/MF A01

The Expert Consultant for Avionics System Transformation Exploitation was developed for rapidly prototyping different alternatives, and to establish the information flow architecture of the avionics system. The tool provides the user with an interface to assist in describing the avionics from the point of view of the data handling, and presents the results in a suitable format; it performs consistency checks and advises the user on possible architectural problems by means of the expert system techniques. The development environment of the tool and how it works in a consulting session are described. ESA

N88-22899# Strathclyde Univ., Glasgow (Scotland).
THE USE OF RULE INDUCTION TO ASSIST IN THE DIAGNOSIS OF AVIONIC CIRCUIT BOARD DEFECTS M.S. Thesis
G. B. SADLER 1987 81 p
(ETN-88-92077) Avail: NTIS HC A05/MF A01

An expert system to assist in the diagnosis of avionic circuit board faults was developed using the rule induction package Intelligence-1. The initial attempt at building an expert system failed but when the level of detail of attributes was altered an expert system was successfully built. The method was proved by building an expert system for a second circuit board using the same approach and by reproducing the same rules for the first board using a different rule induction package, IRIS. The expert system built for the first board was evaluated for accuracy by interrogation using data from additional historical examples and for worth by monitored trials. The former show that the expert system is accurate but not complete and the latter is inconclusive. ESA

N88-22900# VDO-Luftfahrtgeraete Werk Adolf Schindling G.m.b.H., Frankfurt (West Germany).
BASIC DESIGN STUDIES FOR THE REALIZATION OF LIQUID CRYSTAL DISPLAY SYSTEMS IN AIRCRAFT Final Report, Sep. 1986
HANS WERNER FISCHER Bonn, Fed. Republic of Germany Bundesministerium fuer Forschung und Technologie Feb. 1987 75 p In GERMAN; ENGLISH summary
(Contract BMFT-LFL-8376-0)
(VA-87-001; ETN-88-92094) Avail: NTIS HC A04/MF A01

A project to make liquid crystal technology available for displays and display systems in the cockpit of aircraft is discussed. This requires technological studies to select the most suitable type of liquid crystal. Specifications regarding contrast and readability for day and night operation have to be met. Corresponding to the actual applications, compromise solutions have to be found by optimization in order to meet additional, partly contrary, demands on the displays. The study of conditions for realizing a complete display system is given priority. It is to represent monitoring data of engines and auxiliary systems as well as warning signals in a helicopter. The design of the displays includes the display case and electronic control allowing for error recognition and reliability. Special difficulties result from requirements for lower weight and low power input. ESA

N88-22901*# Lockheed-Georgia Co., Marietta.
ANALYTICAL SENSOR REDUNDANCY ASSESSMENT Final Report
D. B. MULCARE, L. E. DOWNING, and M. K. SMITH Apr. 1988 44 p
(Contract NAS2-11853)
(NASA-CR-182892; NAS 1.26:182892; DOT/FAA/CT-86/32)
Avail: NTIS HC A03/MF A01 CSCL 01D

The rationale and mechanization of sensor fault tolerance based on analytical redundancy principles are described. The concept involves the substitution of software procedures, such as an observer algorithm, to supplant additional hardware components. The observer synthesizes values of sensor states in lieu of their direct measurement. Such information can then be used, for example, to determine which of two disagreeing sensors is more correct, thus enhancing sensor fault survivability. Here a stability augmentation system is used as an example application, with required modifications being made to a quadruplex digital flight control system. The impact on software structure and the resultant revalidation effort are illustrated as well. Also, the use of an observer algorithm for wind gust filtering of the angle-of-attack sensor signal is presented. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A88-37191
ADVANCES IN EJECTOR THRUST AUGMENTATION
PAUL M. BEVILAQUA (Lockheed Aeronautical Systems Co., Marietta, GA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 201-215. refs
(SAE PAPER 872322)

Directing the exhaust of a turbojet engine through an ejector pump can significantly increase the jet thrust. This paper is a review of recent advances in the development of thrust augmenting ejectors for VSTOL aircraft. Progress in developing a theory of ejector operation, and related efforts in analysis and prediction will be summarized. Studies of turbulent mixing and duct design which have led to improvements in ejector performance will also be described. Finally, researach problems of current interest and the likely direction of future airplane programs will be discussed. Author

A88-37192
ESTIMATION OF THRUST AUGMENTOR PERFORMANCE IN V/STOL APPLICATIONS
T. S. LUND (Purdue University, West Lafayette, IN), D. A. TAVELLA, and L. ROBERTS (Stanford University, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 217-224. refs
(SAE PAPER 872323)

The performance of two-dimensional thrust augmentors was analyzed by a viscous-inviscid approach, where distinct zones of the augmentor flow-field treated with efficient methodologies, and are then matched together by satisfying required pressure and velocity continuity at zone interfaces. This efficient approach was applied both to a parametric analysis of a standard ejector configuration, where various shroud parameters for arrangements with one or two primary nozzles were considered, and to a limited constrained optimization analysis of inlet shape and nozzle location for a single primary nozzle arrangement. The methodology was validated by quantitative and qualitative comparison with experimental results, and the study provided new insights into thrust augmentor performance as well as practical design guidelines. Author

A88-37193 De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario).
DEVELOPMENT OF LIFT EJECTORS FOR STOVL COMBAT AIRCRAFT
D. B. GARLAND (de Havilland Aircraft Company of Canada, Downsview) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 225-234. Research supported by the Canadian Department of Industry, Trade and Commerce, DND, and NASA. refs
(SAE PAPER 872324)

This paper reviews ejector development at de Havilland Canada (DHC) over the past 25 years, and focuses on the features proposed for the E7 wind tunnel model. The E7 aircraft is a STOVL project study design which utilizes lift ejector technology developed by DHC. Efforts to maximize thrust augmentation ratio within the packaging constraints of typical STOVL aircraft configurations are described. Experimental results from antecedents of the E7 ejector are presented, together with the latest results from full-scale tests at Lewis Research Center, NASA. The major geometrical parameters are described, and their influence on thrust augmentation evaluated. Various nozzle types are discussed. Performance is compared with theoretical trends derived from global compressible theory. A brief look at the installation aerodynamics of a pair of chordwise ejectors, in hover, completes the paper. Author

A88-37196
THRUST EFFICIENCY OF POWERED LIFT SYSTEMS
JOHN L. LOTH and MATHEW FUNK (West Virginia University, Morgantown) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 253-262. Research supported by the Lockheed-Georgia Co. refs
(SAE PAPER 872327)

Two efficiencies have been introduced to facilitate the comparison of powered high lift systems for low approach speed and for acceleration after lift-off. The corresponding minimum thrust and total impulse required by an idealized unpowered wing are used as reference parameters. The efficiencies are shown as a function of installed thrust to weight ratio and minimum flight speed, non-dimensionalized by a reference velocity with dynamic pressure equal to the wing loading. Incorporated in the efficiencies are the effects of wing aerodynamics, engine thrust loss due to power extraction, duct loss and thrust recovery. Author

A88-37199* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLIGHT PROPULSION CONTROL INTEGRATION FOR V/STOL AIRCRAFT
JAMES R. MIHALOEW (NASA, Lewis Research Center, Cleveland, OH) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 303-315. Previously announced in STAR as N88-11680. refs
(SAE PAPER 872330)

The goal of the propulsion community is to have the enabling propulsion technologies in place to permit a low risk decision regarding the initiation of a research STOVL supersonic attack fighter aircraft in the mid-1990's. This technology will effectively integrate, enhance, and extend the supersonic cruise, STOVL, and fighter/attack programs to enable U.S. industry to develop a revolutionary supersonic short takeoff vertical landing fighter/attack aircraft in the post-ATF period. The rationale, methods, and criteria used in developing a joint NASA Lewis and NASA Ames research program to develop the technology element for integrated flight propulsion control through integrated methodologies is presented. This program, the Supersonic STOVL integrated Flight Propulsion Controls Program, is part of the overall NASA Lewis Supersonic STOVL integrated approach to an integrated program to achieve integrated flight propulsion control technology. Author

A88-37213
LIFT ENGINES - APPLIED HISTORY
H. M. HARVEY (Rolls-Royce, PLC, Derby, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 467-476.
(SAE PAPER 872347)

A historical overview is given of lift engines with particular attention given to VTOL. The RB 108, RB 162, and XJ 99 engines are described in detail. Technical experience is discussed with emphasis placed on thrust, weight, volume, intakes, engine stability, stability validation, exhaust gas recirculation, and ground erosion. It is shown that that VTOL aircraft with composite powerplants can be designed and operated successfully. K.K.

A88-37214
STOVL RCS EFFECTS ON PROPULSION SYSTEM DESIGN
LEE COONS (Pratt and Whitney, West Palm Beach, FL) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of

Automotive Engineers, Inc., 1988, p. 477-482. USAF-supported research.
(SAE PAPER 872349)

The reaction control system (RCS) requirements for advanced vertical landing/takeoff aircraft are discussed. It is noted that each aircraft may have differing RCS control requirements resulting in engine bleed flow and pressure requiremets being a function of aircraft design. Consideration is given to projected advanced vertical landing/takeoff missions designed to maintain air superiority near the forward edge of the battle area. RCS thrust/bleed requirements and combustor temperature compensation are addressed as well as the impact of RCS bleed requirements on integrated propulsion/bleed system, and the impact of high levels of bleed air. K.K.

A88-37215* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA SUPERSONIC STOVL PROPULSION TECHNOLOGY PROGRAM
PETER G. BATTERTON and BERNARD J. BLAHA (NASA, Lewis Research Center, Cleveland, OH) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 483-494. Previously announced in STAR as N88-14093. refs
(SAE PAPER 872352)

Supersonic capable STOVL fighter/attack aircraft can provide capabilities for close support and air superiority which will be highly desirable in the future. Previous papers in this session described the historical aspects, trade-offs, and requirements for powered lift propulsion systems, and it is shown that propulsion technology is more key to the success of this type of aircraft than for any previous fighter/attack aircraft. The NASA Lewis Research Center program activities which address required propulsion technology development are discussed. Several elements of this program were initiated which address hot gas ingestion and ejector augmenter performance and some preliminary results are shown. In addition, some additional near-term research activity plans and the new Powered Lift Facility (PLF) research capability are presented. Author

A88-37217* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEST STAND PERFORMANCE OF A CONVERTIBLE ENGINE FOR ADVANCED V/STOL AND ROTORCRAFT PROPULSION
JACK G. MCARDLE (NASA, Lewis Research Center, Cleveland, OH) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 507-517. Previously announced in STAR as N88-11679. refs
(SAE PAPER 872355)

A variable inlet guide vane (VIGV) convertible engine that could be used to power future high-speed V/STOL and rotorcraft was tested on an outdoor stand. The engine ran stably and smoothly in the turbofan, turboshaft, and dual (combined fan and shaft) power modes. In the turbofan mode with the VIGV open, fuel consumption was comparable to that of a conventional turbofan engine. In the turboshaft mode with the VIGV closed, fuel consumption was higher than that of present turboshaft engines because power was wasted in churning fan-tip air flow. In dynamic performance tests with a specially built digital engine control and using a waterbrake dynamometer for shaft load, the engine responded effectively to large steps in thrust command and shaft torque. Author

A88-37228 Department of National Defence, Ottawa (Ontario).
THE SYNTHESIS OF EJECTOR LIFT/VECTORED THRUST FOR STOVL
P. R. SULLY (DND, Ottawa, Canada) and D. C. WHITTLEY IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 657-667. Research sponsored by de Havilland Aircraft Company of Canada, Department of Regional Industrial Expansion, DND, and NASA. refs
(SAE PAPER 872378)

Fundamentals of powered lift for STOL and STOVL are discussed, and the development of Ejector Lift/Vectored Thrust (EL/VT) for multirole supersonic fighter aircraft is considered. Principles of the chordwise ejector concept are reviewed, and a baseline EL/VT layout for the current STOVL studies is proposed. Advantages of the EL/VT concept include that it is not susceptible to hot gas reingestion, that fore and aft distribution of jet lift permits longitudinal distribution of aerodynamic lift and therefore a low level of supersonic wave drag, and that thrust augmentation without fuel consumption permits a more sustained hover. R.R.

A88-37237* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
IMPACT OF BYPASS RATIO ON THRUST-TO-WEIGHT FOR V/STOL
SAMUEL WILSON (NASA, Ames Research Center, Moffett Field, CA) and KATHLEEN MAHONEY (Grumman Aerospace Corp., Bethpage, NY) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 785-795. refs
(SAE PAPER 872348)

Issues involved in the selection of a V/STOL propulsion system are discussed. The effect of bypass ratio on thrust-to-weight, fuel flow, and hover efficiency is investigated for the cases of four representative tilt propulsion system aircraft. The effect of fan pressure ratio on engine selection is shown to be very mission dependent. It is noted that the FAA requires reserves based on fixed wing or helicopter operations, neither of which is found to be entirely appropriate for STOVL aircraft. R.R.

A88-37543
NUMERICAL CALCULATIONS OF THE NATURAL VIBRATIONS OF TURBOMACHINE BLADES USING THE FINITE ELEMENT METHOD [CHISLENNYE RASCHETY SOBSTVENNYKH KOLEBANII LOPATOK TURBOMASHIN S ISPOL'ZOVANIEM MKE]
O. V. REPETSKII (Irkutskii Politekhnicheskii Institut, Irkutsk, USSR) Problemy Prochnosti (ISSN 0556-171X), April 1988, p. 31-36. In Russian. refs

Finite elements for calculating the vibrations of compressor and turbine rotor blades on the basis of shell theory are described. Calculations are carried out for wide-chord and cooled blades, shrouded blades, and blades with antivibration flanges. The numerical calculations are in good agreement with experimental data and other solutions. V.L.

A88-37947*# General Electric Co., Cincinnati, Ohio.
SCALE MODEL ACOUSTIC TESTING OF COUNTERROTATING FANS
B. A. JANARDAN, S. CHUANG, P. Y. HO, and R. LEE (General Electric Co., Cincinnati, OH) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 402-411. refs
(Contract NAS3-24080)
(AIAA PAPER 88-2057)

The UDF contrarotating propfan has been subjected to scale model wind tunnel testing to ascertain both general performance and acoustic characteristics data bases. Model Propulsion Simulator test rigs able to mount contrarotating fan blades of up to 24.5-inch diameter were used, and one of these was installed in a large anechoic test chamber for acoustic measurement of conditions simulating representative takeoffs, power cutbacks, and landing approaches. Attention is presently given to the data acquisition/reduction systems, the scaling criteria used to obtain engine size acoustic data, and comparisons with demonstrator aircraft in-flight acoustic test results. O.C.

A88-39133
CONTROL OF AN AIRCRAFT ELECTRIC FUEL PUMP DRIVE
JIMMIE J. CATHEY (Kentucky, University, Lexington) and JOSEPH A. WEIMER (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IEEE Transactions on Aerospace and Electronics Systems (ISSN 0018-9251), vol. 24, March 1988, p. 171-176. refs
(Contract F33651-81-C-2011)
The concept of designing a high-speed, permanent magnet, brushless DC motor aircraft fuel pump drive using a cycloconverter link is examined. A combination of sinusoidal and DC steady-state analysis is used to produce a simple model of the system. A closed-loop control system with an outer loop based on speed and an inner loop based on current is postulated wherein a proportional-plus-integral controller is placed in the forward path to assure minimum speed error. Gains are then set to assure that the eigenvalues of the linearized control system lie within the left half s-plane over the entire full range. I.E.

A88-39276
COOL EUROPEAN
ALAN POSTLETHWAITE Flight International (ISSN 0015-3710), vol. 133, May 7, 1988, p. 26-29, 32.
The RTM.322 helicopter turboshaft power plant, while currently producing 2100 shp, is being offered to current users of the more technologically mature T700 turboshaft on the strength of the 40-percent power output growth potential inherent in its state-of-the-art design. The discrepancy in output growth is due to the T700's reaching of its turbine inlet temperature limit. The RTM.322's 3000-parts count is claimed to be lower than that of the T700 by some 1500 parts. Both turboshaft and turboprop versions of the engine are under consideration; the turboshaft may be incorporated by such helicopters as the EH.101, UH-60, and AH-64. O.C.

A88-39707* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TURBOFAN ENGINE CORE NOISE SOURCE DIAGNOSTICS
ALLEN M. KARCHMER (NASA, Lewis Research Center, Cleveland, OH) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 121-128. refs
The paper describes a turbofan-engine measurement program utilizing a variety of diagnostic techniques to identify a source of core-generated noise which contributes to the overall external engine noise characteristics. Included in the turbofan engine diagnostics are data examination, time domain correlation, and frequency domain analysis. It is found that the turbulent pressure fluctuations within the combustor are a source for core noise which propagates through the nozzle and radiates to the far-field. K.K.

A88-40554* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN OVERVIEW OF ROTORCRAFT PROPULSION RESEARCH AT LEWIS RESEARCH CENTER
ROBERT C. BILL, GILBERT J. WEDEN (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH), and JOHN J. COY (NASA, Lewis Research Center, Cleveland, OH) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 24-31.
Rotorcraft propulsion research at Lewis Research Center is discussed, stressing programs in four areas of component research: compressors, combustors, turbines and transmissions, and three developmental programs: the Small Turboshaft Engine Research (STER) Project, the Advanced Rotorcraft Transmission (ART) program, and the Compound Cycle Engine (CCE) program. The component research emphasizes special problems of turboshaft engines in the 5 lb/sec to 30 lb/sec range. The objectives of the STER program are to evaluate the application of advanced concepts to small turboshaft engine systems and to investigate system related phenomena, such as distortion effects and secondary flow phenomena. The goals of the ART program are to reduce transmission weight by 25 percent, noise generation by 10 dB and mean time between removal to 5,000 hrs. The CCE program is working to combine the airflow capacity and light-weight features of a gas turbine with the more efficient, but heavier diesel turbine. R.B.

A88-40563
ALLISON GAS TURBINE - IN THE FOREFRONT OF VERTICAL FLIGHT PROPULSION R&D
LOUIS SCIPIONI, JR. (General Motors Corp., Allison Gas Turbine Div., Washington, DC) Vertiflite (ISSN 0042-4455), vol. 34, May-June 1988, p. 116-120.
R&D work on the T800 engine for the Light Helicopter Experimental (LHX) and the T406 turboshaft engine for the V-22 Osprey TiltRotoris discussed. Materials being studied for these engines include improved high-temperature materials such as metal matrix composites, titanium aluminide, and ceramics. Research on engine components includes work on inlet particle separators, sensor development, integration of the propulsion control with the flight control system, and use of CFD in aerothermal analysis. Work is being done to improve maintainability of both engines, using the Engine Monitoring System (EMS) to provide constant information on engine health and computer aided design to allow for development of simplified assembly and disassembly procedures. R.B.

N88-22034# Naval Postgraduate School, Monterey, Calif.
HEAT TRANSFER MODELING OF JET VANE THRUST VECTOR CONTROL (TVC) SYSTEMS M.S. Thesis
MICHAEL F. DULKE Dec. 1987 169 p
(AD-A190106) Avail: NTIS HC A08/MF A01 CSCL 21E
The research presented herein, analyzes two models of a jet vane Thrust Vector Control (TVC) System. Computational modeling was accomplished using the latest version of the PHEONICS computer code, designated PHEONICS-84. The vane configurations studies, consisted of a simple wedge and a blunt bodied vane, with a leading edge radius of 1.016 mm (1/25 in.). These models were examined in a two dimensional, subsonic and supersonic, cold flow field, for both laminar and turbulent flow cases. Results consist of a numerical solution and a graphical representation of surface shear stress coefficient, Stanton number and convective heat transfer coefficient. GRA

N88-22035# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
LINEAR STATE SPACE MODELING OF A TURBOFAN ENGINE Final Report, May 1986 - Dec. 1987
GREGORY L. THELEN Dec. 1987 84 p
(AD-A190110; AFIT/GA/AA/87D-10) Avail: NTIS HC A05/MF A01 CSCL 21E
The F101 turbofan engine, used on the B-1B bomber, will be used as the example with the linear state space models being derived from the non-linear F101 engine computer simulation model. The internal convergence logic of the F101 engine simulation will be used to derive the individual elements making up the linear state space models. The linear state space models will consist of both high speed and low speed rotor dynamics and turbine inlet temperature heat soak dynamics. State space inputs considered will be fuel flow and engine exit nozzle area. Also disussed in this paper will be linear analytic equations in state space format and their comparative accuracies to the models derived using the F101 non-linear computer simulation model. Based on the linear state space models developed in this paper, control systems will be designed and implemented into the F101 engine computer model. Transient performance will be compared between current engine control design and the control design based on the linear state space models. Final results will confirm the validity of the state space models derived by showing improvement over current engine transient performance. GRA

N88-22036# Purdue Univ., West Lafayette, Ind. Thermal Sciences and Propulsion Center.
RESEARCH AS PART OF THE AIR FORCE IN AERO PROPULSION TECHNOLOGY (AFRAPT) PROGRAM Annual Summary Report, Aug. 1986 - Aug. 1987
SANFORD FLEETER Aug. 1987 5 p
(Contract AF-AFOSR-0305-86)
(AD-A190336; AFOSR-87-1763TR) Avail: NTIS HC A02/MF A01 CSCL 01C

Seven students participated in the Air Force Research in Aero Propulsion Technology (AFRAPT) program during the 1986 to 1987 academic year. During this year: one new Ph.D. candidate successfully completed his qualifying exams and initiated his thesis research; one continuing M.S.M.E. candidate has nearly completed his experimental thesis research; five new M.S.M.E. candidates have completed most of their course work and have initiated their thesis research. GRA

N88-22037*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SMALL ENGINE COMPONENTS TEST FACILITY TURBINE TESTING CELL
BRENT C. NOWLIN and VINCENT G. VERHOFF 1988 17 p
Prepared for presentation at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored in part by AIAA, ASEE, ASME, and SAE
(NASA-TM-100887; E-4120; NAS 1.15:100887; AIAA-88-2963)
Avail: NTIS HC A03/MF A01 CSCL 21E

NASA Lewis Research Center has designed and constructed a new state-of-the-art test facility. This facility, called the Small Engine Components Test Facility (SECTF), is used to test gas turbines and compressors at conditions similar to actual engine conditions. The SECTF is comprised of two separate facilities - a turbine test cell and a compressor test cell. The paper will describe the turbine test cell. The capabilities of the facility make it unique - no other facility of its kind is capable of combining its pressure, speed, and temperature ranges. Turbine inlet air ranges up to 9 atm (125 psig). The turbine exhaust pressure ranges from 0.15 atm (2 psia) to atmospheric pressure. Turbine inlet air temperatures range from ambient to 700 K (1260 deg R). The controllable speed of the turbine rotor ranges from 4000 to 60,000 rpm and the maximum power absorbed by the facility dynamometer is 1250 hp. The data acquisition system scans up to 2000 channels/sec. This paper will discuss in detail the capabilities of the facility, overall facility design, instrumentation used in the facility, and the data acquisition system. Actual research data is not discussed. Author

N88-22383*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-TEMPERATURE COMBUSTOR LINER TESTS IN STRUCTURAL COMPONENT RESPONSE TEST FACILITY
PAUL E. MOORHEAD *In its* Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 5-13 May 1988
Avail: NTIS HC A14/MF A01 CSCL 21E

Jet engine combustor liners were tested in the structural component response facility at NASA Lewis. In this facility combustor liners were thermally cycled to simulate a flight envelope of takeoff, cruise, and return to idle. Temperatures were measured with both thermocouples and an infrared thermal imaging system. A conventional stacked-ring louvered combustor liner developed a crack at 1603 cycles. This test was discontinued after 1728 cycles because of distortion of the liner. A segmented or float wall combustor liner tested at the same heat flux showed no significant change after 1600 cycles. Changes are being made in the facility to allow higher temperatures. Author

N88-22384*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIFE ASSESSMENT OF COMBUSTOR LINER USING UNIFIED CONSTITUTIVE MODELS
M. T. TONG (Sverdrup Technology, Inc., Cleveland, Ohio.) and R. L. THOMPSON *In its* Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 15-25 May 1988
(Contract NAS3-24105)
Avail: NTIS HC A14/MF A01 CSCL 21E

Hot section components of gas turbine engines are subject to severe thermomechanical loads during each mission cycle. Inelastic deformation can be induced in localized regions leading to eventual fatigue cracking. Assessment of durability requires reasonably accurate calculation of the structural response at the critical location for crack initiation. In recent years nonlinear finite element computer codes have become available for calculating inelastic structural response under cyclic loading. NASA-Lewis sponsored the development of unified constitutive material models and their implementation in nonlinear finite element computer codes for the structural analysis of hot section components. These unified models were evaluated with regard to their effect on the life prediction of a hot section component. The component considered was a gas turbine engine combustor liner. A typical engine mission cycle was used for the thermal and structural analyses. The analyses were performed on a CRAY computer using the MARC finite element code. The results were compared with laboratory test results, in terms of crack initiation lives. Author

N88-22390*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE COMPOSITE BLADE STRUCTURAL ANALYZER (COBSTRAN)
ROBERT A. AIELLO *In its* Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 83-97 May 1988
Avail: NTIS HC A14/MF A01 CSCL 21E

The use and application of the COBSTRAN (COmposite Blade STRuctural ANalyzer) computer code is presented. COBSTRAN was developed at NASA-Lewis and is currently being used for the design and analysis of aircraft engine ducted and unducted fan blades. The features of COBSTRAN are demonstrated for the modeling and analysis of a scaled down wind tunnel model propfan blade made from fiber composites. Comparison of analytical and experimental mode shapes and frequencies are shown, verifying the model development and analysis techniques used. The methodologies and programs developed for this analysis are directly applicable to other propfan blades. Author

N88-22394*# MARC Analysis Research Corp., Palo Alto, Calif.
MHOST: AN EFFICIENT FINITE ELEMENT PROGRAM FOR INELASTIC ANALYSIS OF SOLIDS AND STRUCTURES
S. NAKAZAWA *In* NASA. Lewis Research Center, Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 131-140 May 1988
(Contract NAS3-23698)
Avail: NTIS HC A14/MF A01 CSCL 21E

An efficient finite element program for 3-D inelastic analysis of gas turbine hot section components was constructed and validated. A novel mixed iterative solution strategy is derived from the augmented Hu-Washizu variational principle in order to nodally interpolate coordinates, displacements, deformation, strains, stresses and material properties. A series of increasingly sophisticated material models incorporated in MHOST include elasticity, secant plasticity, infinitesimal and finite deformation plasticity, creep and unified viscoplastic constitutive model proposed by Walker. A library of high performance elements is built into this computer program utilizing the concepts of selective reduced integrations and independent strain interpolations. A family of efficient solution algorithms is implemented in MHOST for linear and nonlinear equation solution including the classical Newton-Raphson, modified, quasi and secant Newton methods with optional line search and the conjugate gradient method. Author

N88-22399*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTATIONAL STRUCTURAL MECHANICS FOR ENGINE STRUCTURES
CHRISTOS C. CHAMIS *In its* Lewis Structures Technology, 1988.

Volume 2: Structural Mechanics p 189-203 May 1988
Avail: NTIS HC A14/MF A01 CSCL 21E

The computational structural mechanics (CSM) program at Lewis encompasses the formulation and solution of structural mechanics problems and the development of integrated software systems to computationally simulate the performance, durability, and life of engine structures. It is structured to supplement, complement, and, whenever possible, replace costly experimental efforts. Specific objectives are to investigate unique advantages of parallel and multiprocessing for reformulating and solving structural mechanics and formulating and solving multidisciplinary mechanics and to develop integrated structural system computational simulators for predicting structural performance, evaluating newly developed methods, and identifying and prioritizing improved or missing methods. Author

N88-22431*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REVIEW AND ASSESSMENT OF THE HOST TURBINE HEAT TRANSFER PROGRAM
HERBERT J. GLADDEN *In its* Lewis Structures Technology, 1988. Volume 3: Structural Integrity Fatigue and Fracture Wind Turbines HOST p 349-367 May 1988
Avail: NTIS HC A16/MF A01 CSCL 21E

The objectives of the HOST Turbine Heat Transfer subproject were to obtain a better understanding of the physics of the aerothermodynamic phenomena occurring in high-performance gas turbine engines and to assess and improve the analytical methods used to predict the fluid dynamics and heat transfer phenomena. At the time the HOST project was initiated, an across-the-board improvement in turbine design technology was needed. Therefore, a building-block approach was utilized, with research ranging from the study of fundamental phenomena and analytical modeling to experiments in simulated real-engine environments. Experimental research accounted for 75 percent of the project, and analytical efforts accounted for approximately 25 percent. Extensive experimental datasets were created depicting the three-dimensional flow field, high free-stream turbulence, boundary-layer transition, blade tip region heat transfer, film cooling effects in a simulated engine environment, rough-wall cooling enhancement in a rotating passage, and rotor-stator interaction effects. In addition, analytical modeling of these phenomena was initiated using boundary-layer assumptions as well as Navier-Stokes solutions. Author

N88-22902*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA ADVANCED TURBOPROP RESEARCH AND CONCEPT VALIDATION PROGRAM
JOHN B. WHITLOW, JR. and G. KEITH SIEVERS 1988 23 p
Proposed for presentation at the 1988 Conference and Exposition on Future Transportation Technology, San Francisco, Calif., 8-11 Aug. 1988; sponsored by the Society of Automotive Engineers
(NASA-TM-100891; E-4129; NAS 1.15:100891) Avail: NTIS HC A03/MF A01 CSCL 21E

NASA has determined by experimental and analytical effort that use of advanced turboprop propulsion instead of the conventional turbofans in the older narrow-body airline fleet could reduce fuel consumption for this type of aircraft by up to 50 percent. In cooperation with industry, NASA has defined and implemented an Advanced Turboprop (ATP) program to develop and validate the technology required for these new high-speed, multibladed, thin, swept propeller concepts. This paper presents an overview of the analysis, model-scale test, and large-scale flight test elements of the program together with preliminary test results, as available. Author

N88-23247*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
AEROELASTIC FORCED RESPONSE ANALYSIS OF TURBOMACHINERY
TODD E. SMITH (Sverdrup Technology, Inc., Cleveland, Ohio.) *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 287-297 May 1988
(Contract NAS3-24105)
Avail: NTIS HC A20/MF A01 CSCL 21E

An introduction is given to the research activity that is underway to enable the prediction of turbomachinery aeroelastic forced response. An effort is being made to assemble a computer program (FREPS) which incorporates the aeroelastic structural models, unsteady aerodynamic models, and forcing function models. The structural and aerodynamic models are currently well developed. The forcing function models are at a primitive level. A significant activity has begun to identify the forcing functions due to stator-rotor aerodynamic interaction. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A88-37198* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INTEGRATED CONTROL AND DISPLAY RESEARCH FOR TRANSITION AND VERTICAL FLIGHT ON THE NASA V/STOL RESEARCH AIRCRAFT (VSRA)
JOHN D. FOSTER, ERNESTO MORALEZ, III, JAMES A. FRANKLIN (NASA, Ames Research Center, Moffett Field, CA), and JEFFREY A. SCHROEDER (NASA, Ames Research Center; U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 279-301. Previously announced in STAR as N88-13359. refs
(SAE PAPER 872329)

Results of a substantial body of ground-based simulation experiments indicate that a high degree of precision of operation for recovery aboard small ships in heavy seas and low visibility with acceptable levels of effort by the pilot can be achieved by integrating the aircraft flight and propulsion controls. The availability of digital fly-by-wire controls makes it feasible to implement an integrated control design to achieve and demonstrate in flight the operational benefits promised by the simulation experience. It remains to validate these systems concepts in flight to establish their value for advanced short takeoff vertical landing (STOVL) aircraft designs. This paper summarizes analytical studies and simulation experiments which provide a basis for the flight research program that will develop and validate critical technologies for advanced STOVL aircraft through the development and evaluation of advanced, integrated control and display concepts, and lays out the plan for the flight program that will be conducted on NASA's V/STOL Research Aircraft (VSRA). Author

A88-37200
THE VAAC VSTOL FLIGHT CONTROL RESEARCH PROJECT
O. P. NICHOLAS (Royal Aircraft Establishment, Bedford, England) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 317-322.
(SAE PAPER 872331)

Flight control systems for advanced VSTOL aircraft present unique challenges and opportunities. The designer must address a broad range of questions on control laws, displays and inceptors (cockpit controls). VAAC is a programme of research into advanced VSTOL flight control. Its objective is to develop concepts, and design and assessment techniques. It takes studies through piloted ground-based simulation to flight in the RAE VAAC research Harrier. The experimental flight control system fitted to the VAAC aircraft has been designed to permit a wide range of experimental laws to be flown safely. Author

A88-37201
A HIGHLY MONITORED AV-8B HARRIER II DIGITAL FLIGHT CONTROL SYSTEM
V. L. MIGBEE, G. G. GASTON, and K. W. GIBBAR (McDonnell Douglas Corp., Saint Louis, MO) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 323-335.
(SAE PAPER 872332)

The AV-8B Harrier II incorporates a limited-authority digital Stability Augmentation and Attitude Hold System (SAAHS); this single-channel electronic flight control system requires a self-test/monitoring system that is implemented in three primary categories: hardware, software monitor of hardware, and software monitor of performance. Overall system health is determined by preflight BIT. System performance during flight is continuously monitored. The SAAHS meets the requirement for detection of 98 percent of all possible failures, and isolation of 99 percent of detected failures to a faulty weapons-replaceable assembly in the ground BIT mode. O.C.

A88-37203
STABILITY AND CONTROL AUGMENTATION SYSTEM OF 'ASKA'
NORIAKI OKADA, TOSHIO BANDO (National Aerospace Laboratory, Chofu, Japan), OSAMU KOBAYASHI, and TAKASHI TSUJIMOTO (Kawasaki Heavy Industries, Ltd., Kobe, Japan) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 349-355. refs
(SAE PAPER 872334)

'ASKA' is a STOL airplane with Upper Surface Blown (USB) flaps and is used to perform research on powered lift technology by Japan's National Aerospace Laboratory. ASKA has four high bypass ratio turbofan engines mounted above and forward of the wings, hydraulically actuated flight controls, and the Stability and Control Augmentation System (SCAS). The SCAS is a triple-redundant system with three digital computers. In order to develop and evaluate its control laws, flight simulator tests have been conducted for 9 years during the design phase. Four flights have been devoted to evaluate functions of the SCAS and the control laws. The significant features of the control laws are to realize satisfactory flying qualities in the deep backside region at low airspeeds. As ASKA has not been tested in such regions up to present, this paper includes only the design features of the SCAS control laws, the results of the flight simulator tests, and interim outcomes of the flight tests on shallow USB flap configurations. Author

A88-38191#
A STUDY OF DIGITAL FLY-BY-WIRE CONTROL SYSTEM DESIGN FOR ELASTIC AIRCRAFT
LICHUN LI (Institute of Automatic Flight Control Systems, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Feb. 1988, p. B41-B50. In Chinese, with abstract in English.

Design research on the aeroservoelastic effects of a high-performance aircraft using ACT is presented. The method of analysis and design of a DFBW control system and the structure modes of aircraft are considered. The caulping equations which separate the general equations into rigid and structure modes are established. The elastic transfer function of the main internal loop of DBW systems is introduced for a typical first-order longitudinal fuselage bending mode. A design example using the reference aircraft is given. C.D.

A88-38192#
CONTROL LAW DESIGN OF A CCV AIRPLANE
GANG FENG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Feb. 1988, p. B51-B57. In Chinese, with abstract in English.

In this paper, a method is presented for the design of control laws of a CCV airplane via eigenstructure assignment, i.e., the eigenvectors of a closed-loop system are selected to decouple the corresponding states of the aircraft, and to realize the CCV control laws of the airplane. The controllers of pitch-pointing and vertical translation modes are designed for an airplane. The simulation results of two modes are excellent. Author

A88-38737*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
EFFECTS OF MANEUVER DYNAMICS ON DRAG POLARS OF THE X-29A FORWARD-SWEPT-WING AIRCRAFT WITH AUTOMATIC WING CAMBER CONTROL
JOHN W. HICKS and BRYAN J. MOULTON (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 312-322. refs
(AIAA PAPER 88-2144)

The camber control loop of the X-29A FSW aircraft was designed to furnish the optimum L/D for trimmed, stabilized flight. A marked difference was noted between automatic wing camber control loop behavior in dynamic maneuvers and in stabilized flight conditions, which in turn affected subsonic aerodynamic performance. The degree of drag level increase was a direct function of maneuver rate. Attention is given to the aircraft flight drag polar effects of maneuver dynamics in light of wing camber control loop schedule. The effect of changing camber scheduling to better track the optimum automatic camber control L/D schedule is discussed. O.C.

A88-38747*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
PERFORMANCE IMPROVEMENTS OF AN F-15 AIRPLANE WITH AN INTEGRATED ENGINE-FLIGHT CONTROL SYSTEM
LAWRENCE P. MYERS and KEVIN R. WALSH (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 410-418. refs
(AIAA PAPER 88-2175)

An integrated flight and propulsion control system has been developed and flight demonstrated on the NASA Ames-Dryden F-15 research aircraft. The highly integrated digital control (HIDEC) system provides additional engine thrust by increasing engine pressure ratio (EPR) at intermediate and afterburning power. The amount of EPR uptrim is modulated based on airplane maneuver requirements, flight conditions, and engine information. Engine thrust was increased as much as 10.5 percent at subsonic flight conditions by uptrimming EPR. The additional thrust significantly improved aircraft performance. Rate of climb was increased 14 percent at 40,000 ft and the time to climb from 10,000 to 40,000 ft was reduced 13 percent. A 14 and 24 percent increase in acceleration was obtained at intermediate and maximum power, respectively. The HIDEC logic performed fault free. No engine anomalies were encountered for EPR increases up to 12 percent and for angles of attack and sideslip of 32 and 11 deg, respectively. Author

A88-39485
COMPUTER VISION FOR FLIGHT VEHICLES
E. D. DICKMANNS (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, Mar.-Apr. 1988, p. 71-79. refs

The application of computer vision (CV) to aircraft is discussed, with a focus on a CV system for the final landing approach. The history and fundamental principles of CV are reviewed; advances in computing power, AI, and sensor technology are described; and applications such as on-request crew support, independent monitoring, improved autopilots, landmark navigation, and advanced RPVs are briefly characterized. Particular attention is given to real-time numerical simulations of 60-70-m/sec business-jet landing approaches, performed at the Universitaet der

Bundeswehr in Munich. In these simulations, feature-based image processing using an appropriately defined world model is realized with a cycle time of 100 msec, and the only additional input to the landing control is the airspeed. The perspective mapping, dynamic models, trajectory shape, and state-feedback controls are explained, and the results are presented graphically. T.K.

A88-39622
THE CONTROLLED SYSTEM AS A SYSTEM WITH NONHOLONOMIC CONSTRAINTS - THE CASE OF A HELICOPTER [LE SYSTEME COMMANDE ET TANT QUE SYSTEME A LIAISONS NON HOLONOMES - CAS D'UN HELICOPTERE]
K. JANKOWSKI (Wyzsza Szkola Inzynierska, Radom, Poland) and J. MARYNIAK (Warszawa, Politechnika, Warsaw, Poland) Journal de Mecanique Theorique et Appliquee (ISSN 0750-7240), vol. 7, no. 2, 1988, p. 157-173. In French. refs

The motion of mechanical systems subjected to the constraints imposed by an automatic control system is investigated. A complete mathematical model of an automatically controlled helicopter is developed using the quasi-coordinate Boltzmann-Hamel equations for nonholonomic systems. The theory takes into account several degrees of freedom of the helicopter, which is treated as a rigid body. The problem of the presence of periodic coefficients is overcome by determining the angular coordinates of the main rotor and the tail rotor in a Fourier series, retaining only the first-order harmonics. R.R.

A88-40526#
STATUS AND TREND IN CCV
SABURO OGINO and TAKAO OSHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 405, 1987, p. 460-467. In Japanese. refs

A88-40527#
DEVELOPMENT OVERVIEW OF THE T-2 CCV
HIDEJIRO YAMADA, HIDEKI KANNO, AKIHIRO TAKEKOSHI, YUTAKA HINENO, and AKIO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 405, 1987, p. 475-481. In Japanese.

A88-40528#
FBW SYSTEM AND CONTROL LAW OF THE T-2 CCV
MASAHIRO YASUE, AKIRA KUBO, TADASHI KAMEYAMA, MORIO TAKAHAMA, RYOJI KATAYANAGI et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 405, 1987, p. 482-492. In Japanese. refs

A88-40529#
FLIGHT TESTING RESULTS OF T-2 CCV
MASATO NAKAO, KATSUHEI SHIBATA, MASASHIRO IDE, YOSHIO ASANO, HIDEAKI OHMIYA et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 405, 1987, p. 492-500. In Japanese. refs

A88-40706*#
THE EFFECTS OF CANARD-WING FLOW-FIELD INTERACTIONS ON LONGITUDINAL STABILITY, EFFECTIVE DIHEDRAL AND POTENTIAL DEEP-STALL TRIM
C. B. MUCHMORE, JR. IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 40-50. Research supported by the Joint Institute for the Advancement of Flight Sciences and NASA. refs
(AIAA PAPER 88-2514)

The literature available on high aspect ratio canard configurations shows them to have some unique stability characteristics. Using a generic canard-wing model, the effects of canard-wing flow-field interactions on stability were investigated in the NASA Langley Twelve-Foot Low-Speed Wind Tunnel. Results for the attached flow regime indicate linear interactions shift the neutral point of a canard configuration forward, but the effect of a canard on a wing can change significantly when the flow over the surface begins to separate, even several degrees below stall. The asymmetry of the canard downwash in a sideslip condition can result in an increment in effective dihedral roughly proportional to canard lift coefficient. At very high angles of attack the presence of a wing can cause an incremental normal force on a canard, contributing to the possibility of a deep-stall trim point. This effect is greater for a high canard and less for a low one. Author

A88-40858#
DECENTRALIZED APPROACH TO THE DESIGN OF AUTOMATIC FLIGHT CONTROL SYSTEMS [DETSENTRALIZOVANI PRILAZ PROJEKTOVANJU AUTOMATSKOG SISTEMA UPRAVLJANJA LETOM]
M. VUKOBRATOVICH and R. STOJICH Srpska Akademija Nauka i Umetnosti, Glas, Odeljenje Tekhnichkikh Nauka, no. 25, 1988, p. 83-106. In Serbo-Croatian. refs

An approach to the decentralized control of large-scale nonlinear systems is applied to dynamic flight control. Control synthesis is performed in two steps: (1) the synthesis of the nominal, programmed control using the complete flight-dynamics model and (2) tracking of the nominal trajectory. A choice of subsystems is proposed for a particular case of flight control, and local and global control synthesis is proposed. A flight control simulation with the proposed control law is presented. B.J.

N88-22038# National Aerospace Lab., Amsterdam (Netherlands).
DESIGN OF AN INTEGRATED CONTROL SYSTEM FOR FLUTTER MARGIN AUGMENTATION AND GUST LOAD ALLEVIATION, TESTED ON A DYNAMIC WINDTUNNEL MODEL
P. A. VANGELDER 12 May 1986 17 p Presented at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(PB88-149885; NLR-MP-86034-U) Avail: NTIS HC A03/MF A01 CSCL 01C

The design method is described and some results are given from wind tunnel tests of a digitally implemented, integrated control system for both flutter augmentation and gust load alleviation. The control system was designed using optimization techniques applied to a reduced order output controller. Either the ailerons or the spoilers were used as control surfaces, while tailplanes and rudder were used additionally for rigid body mode control. Author

N88-22039# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
APPLICATION OF EIGENSTRUCTURE ASSIGNMENT TECHNIQUES IN THE DESIGN OF A LONGITUDINAL FLIGHT CONTROL SYSTEM M.S. Thesis
DANIEL G. GODDARD Sep. 1987 121 p
(AD-A189644; AFIT/GAE/AA/87S-2) Avail: NTIS HC A06/MF A01 CSCL 01A

The use of eigenstructure assignment techniques has received wide attention as a tool for designing flight control systems for aircraft with multiple control surfaces. Development of a method for choosing the desired eigenstructure of the augmented, closed-loop system which would meet the handling qualities specifications was examined. This method consisted of forming an optimal plant matrix which possessed desirable dynamic characteristics and performing a spectral decomposition of this matrix. The resulting eigenstructure was used as the desired eigenvalues and eigenvectors during the full-state feedback, eigenstructure assignment process. The resulting feedback gain matrix was used in the control system. This process was performed on a model of the X-29A using the canard, flaperon, and strake flap control surfaces. The resulting augmented system was evaluated using the Neal-Smith pilot-model analysis and also using an X-29A man-in-the-loop simulation. The results show that the method is very promising, although care must be taken that all anticipated control system dynamics are considered when forming the optimal A matrix. GRA

N88-22040# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MULTIVARIABLE CONTROL LAW DESIGN FOR THE AFTI/F-16 WITH A FAILED CONTROL SURFACE USING A PARAMETER-ADAPTIVE CONTROLLER M.S. Thesis
JULIO E. VELEZ Dec. 1987 183 p
(AD-A189848; AFIT/GE/ENG/87D-69) Avail: NTIS HC A09/MF A01 CSCL 01D

Multivariable control laws are designed for the Advanced Fighter Technology Integration F-16 (AFTI/F-16). Both fixed gain and adaptive Proportional plus Integral (PI) controllers are designed for a plant were the number of outputs are not equal to the number of inputs (rectangular plant). Simulations are conducted for a healthy and a failed aircraft model. The failure consists of reducing the left elevator by 50 percent. When the fixed gain controller is used for the flight control system, the simulation reveals the fact that the aircraft failure causes the output responses to diverge. If provided with a persistently exciting input the adaptive controller prevents the aircraft failure simulation from diverging and going unstable. However, additional testing and/or tuning of the adaptive controller is required to determine and enhance the stability of the adaptive controller. GRA

N88-22041# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
KALMAN FILTER RESIDUAL EXPERT SYSTEM M.S. Thesis
JEFFREY D. GRIMSHAW Dec. 1987 189 p
(AD-A190520; AFIT/GCE/ENG/87D-4) Avail: NTIS HC A09/MF A01 CSCL 12E

The Pilot's Associate (PA) program has been initiated to help mitigate the extensive workload of the fighter pilot. To operate effectively, the PA system must have situation awareness: the status of important on-board and off-board systems. This knowledge is gained through sensor systems. The data from these systems must be fused together to present the PA with a coherent picture of the internal (on-board) and external (off-board) states. Although many types of information can be extracted from sensor data, this paper emphasizes those parameters that help determine target track. One common technique for fusing sensor data uses Kalman filters. In a multiple model adaptive filter (MMAF) system, the most appropriate Kalman filter is chosen. This filter provides the best estimates of the desired states. An operating MMAF system continually selects which filter to use as the basis for the state estimates. The overall accuracy of the system is closely related to how well the filters are selected. Previous filter selection techniques have proved useful, but limited. To overcome some of these limitations, an expert system, KREST, was developed so that expert rules could be used to select filters. GRA

N88-22042# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
SUBHARMONIC ALIASING AND ITS EFFECTS ON THE AFTI/F-16 DIGITAL FLIGHT CONTROL SYSTEM M.S. Thesis
DAVID M. THOMAS Dec. 1987 114 p
(AD-A190614; AFIT/GE/ENG/87D-66) Avail: NTIS HC A06/MF A01 CSCL 01D

The purpose of this research is threefold. First, determine the cause of subharmonic aliasing, described by the AFTI/F-16 engineers as the creation of uncorrelated low frequencies whenever a subharmonic of the sample frequency is input into the system. Second, model the subharmonic aliasing effect, so that, by knowing only input frequency and the system sample rate the output characteristics can be calculated. And third, demonstrate by simulation the effect of input and output filters on the subharmonic alias, and the effect of signals in the subharmonic range (omega(N)/10 less than omega(0) less than omega(S)/2) on the interchannel difference and the software rate limiter. The model determined that subharmonic aliasing is the result of imposter frequencies (much like aliasing) being introduced into the output signal by the sampling process. We defined subharmonic aliases occur due to: imposter frequencies and a phenomena known as apparent low frequency surge, which occurs when the input frequency is nearly an integer multiple (greater than 1) of the imposter frequency. GRA

N88-22903# European Space Agency, Paris (France).
SERVO-ACTUATOR CONTROL FOR SAMPLED-DATA FEEDBACK DISTURBANCE REJECTION
JOSEF PETRY (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) Nov. 1987 221 p Transl. into ENGLISH of Zur Ansteuerung von Servoaktuatoren fuer die Stoergroessenkompensation mittels Abtastsystemen (Oberpfaffenhofen, Fed. Republic of Germany, DFVLR), Jan. 1986 199 p Original language document was announced as N88-32446
(ESA-TT-1002; DFVLR-FB-86-08; ETN-88-91974) Avail: NTIS HC A10/MF A01; original German version available from DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 57.50 DM

Based on a helicopter it is demonstrated why discrete feedback control for disturbance rejection using a pulse-amplitude-modulated control signal can cause undesired disturbing effects. This analysis is done in the frequency domain by frequency, and by spectral decompositions of the signals concerned. The results provide recommendations for a controller design. A continuous minor-loop feedback control which allows the continuous plant to be appropriately adjusted to the characteristics of discrete disturbance rejection is proposed. The efficiency of this approach is confirmed by design examples and simulations. ESA

N88-22904*# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
ANALYSIS AND DESIGN OF GAIN SCHEDULED CONTROL SYSTEMS Ph.D. Thesis
JEFF S. SHAMMA May 1988 203 p
(Contract NAG2-297)
(NASA-CR-182867; NAS 1.26:182867; LIDS-TH-1770) Avail: NTIS HC A10/MF A01 CSCL 01C

Gain scheduling, as an idea, is to construct a global feedback control system for a time varying and/or nonlinear plant from a collection of local time invariant designs. However in the absence of a sound analysis, these designs come with no guarantees on the robustness, performance, or even nominal stability of the overall gain schedule design. Such an analysis is presented for three types of gain scheduling situations: (1) a linear parameter varying plant scheduling on its exogenous parameters, (2) a nonlinear plant scheduling on a prescribed reference trajectory, and (3) a nonlinear plant scheduling on the current plant output. Conditions are given which guarantee that the stability, robustness, and performance properties of the fixed operating point designs carry over to the global gain scheduled designs, such as the scheduling variable should vary slowly and capture the plants nonlinearities. Finally, an alternate design framework is proposed which removes the slowing varying restriction or gain scheduled systems. This framework addresses some fundamental feedback issues previously ignored in standard gain. Author

N88-22905*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN INVESTIGATION OF THE ABILITY TO RECOVER FROM TRANSIENTS FOLLOWING FAILURES FOR SINGLE-PILOT ROTORCRAFT
M. HOSSEIN MANSUR and JEFFERY A. SCHROEDER May 1988 43 p
(NASA-TM-100078; A-88113; USAAVSCOM-TM-88-A-001; NAS 1.15:100078) Avail: NTIS HC A03/MF A01 CSCL 01C

A moving-base simulation was conducted to investigate a pilot's ability to recover from transients following single-axis hard-over failures of the flight-control system. The investigation was performed in conjunction with a host simulation that examined the influence of control modes on a single pilot's ability to perform various mission elements under high-workload conditions. The NASA Ames large-amplitude-motion Vertical Motion Simulator (VMS) was utilized, and the experimental variables were the failure axis, the severity of the failure, and the airspeed at which the failure occurred. Other factors, such as pilot workload and terrain and obstacle proximity at the time of failure, were kept as constant as possible within the framework of the host simulation task scenarios. No explicit failure warnings were presented to the pilot. Data from the experiment are shown, and pilot ratings are compared with the proposed handling-qualities requirements for military rotorcraft. Results indicate that the current proposed failure transient requirements may need revision. Author

N88-22906# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
STABILITY AND CONTROL METHODOLOGY FOR CONCEPTUAL AIRCRAFT DESIGN. VOLUME 1: METHODOLOGY MANUAL Final Report, Jun. 1985 - Jun. 1987
TERRY S. SMITH Dec. 1987 179 p
(AD-A191314; AFWAL-TR-87-3115-VOL-1) Avail: NTIS HC A09/MF A01 CSCL 01A

This report contains methodology for predicting stability and control characteristics of conceptual flight vehicles. The methodology presented is a combination of existing methodology, modified existing methodology, and newly developed methodology. The methodology is divided into three main sections: (1) Aerodynamics of Longitudinal stability coefficients, (2) Lateral Stability coefficients, and (3) Static and Dynamic Stability Analysis. GRA

N88-23249*# Georgia Inst. of Tech., Atlanta.
APPLICATION OF NAVIER-STOKES ANALYSIS TO STALL FLUTTER
J. C. WU, R. SRIVASTAVA, and L. N. SANKAR *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 309-320 May 1988
(Contract NAG3-730)
Avail: NTIS HC A20/MF A01 CSCL 01A

A solution procedure was developed to investigate the two-dimensional, one- or two-dimensional flutter characteristics of arbitrary airfoils. This procedure requires a simultaneous integration in time of the solid and fluid equations of motion. The fluid equations of motion are the unsteady compressible Navier-Stokes equations, solved in a body-fitted moving coordinate system using an approximate factorization scheme. The solid equations of motion are integrated in time using an Euler implicit scheme. Flutter is said to occur if small disturbances imposed on the airfoil attitude lead to divergent oscillatory motions at subsequent times. The flutter characteristics of airfoils in subsonic speed at high angles of attack and airfoils in high subsonic and transonic speeds at low angles of attack are investigated. The stall flutter characteristics are also predicted using the same procedure. Author

N88-23250*# Toledo Univ., Ohio.
A COMPUTATIONAL PROCEDURE FOR AUTOMATED FLUTTER ANALYSIS
DURBHA V. MURTHY *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 323-336 May 1988 Previously announced as N87-28058
Avail: NTIS HC A20/MF A01 CSCL 01A

A direct solution procedure for computing the flutter Mach number and the flutter frequency is applied to the aeroelastic analysis of propfans using an unsteady aerodynamic model based on a three-dimensional subsonic compressible lifting surface theory. An approximation to the Jacobian matrix that improves the efficiency of the iterative process is presented. The Jacobian matrix is indirectly approximated from approximate derivatives of the flutter matrix. Examples are used to illustrate the convergence properties. The direct solution procedure facilitates the automated flutter analysis in addition to contributing to the efficient use of computer time as well as the analyst's time. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A88-37182
LANDING SURFACE CHARACTERISTICS UNIQUE TO V/STOL AIRCRAFT
HAROLD FLUK (U.S. Naval Air Engineering Center, Lakehurst, NJ) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 87-99. refs
(SAE PAPER 872310)

This article presents work performed at the Naval Air Engineering Center involving V/STOL Aircraft ground flows. Exhaust flows are directly related to aircraft size (thrust level) and propulsion system size (disk loading). A brief commentary on ground flow phenomena through the full range of disk loading is given. Major discussion is devoted to the narrower band of disk loading attendant with high performance V/STOL Aircraft. In particular, gas velocities and temperatures in the ground flow surroundings, and characteristics of pervasiveness are described. Heat transfer into a uniform structure has been calculated for concrete, poly/resin, asphalt, aluminum, and steel. Resultant surface and internal temperature distributions are shown. The influence of engine exhaust temperature, height above ground, and heating time is illustrated. Jet engine exhaust impingement tests of refractory concretes, asphalt, and aluminum have been conducted and compared with heat transfer computations. Material samples were subjected to afterburning gases at 3150 F and 2.5 atmospheres through prescribed heating and cool down cycles. Materials found capable of withstanding such high energy jets are described. Author

A88-37197* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC FLOW QUALITY AND ACOUSTIC CHARACTERISTICS OF THE 40- BY 80-FOOT TEST SECTION CIRCUIT OF THE NATIONAL FULL-SCALE AERODYNAMIC COMPLEX
LAWRENCE E. OLSON, PETER T. ZELL, PAUL T. SODERMAN, MICHAEL D. FALARSKI, VICTOR R. CORSIGLIA, and H. KIPLING EDENBOROUGH (NASA, Ames Research Center, Moffett Field, CA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 263-278. refs
(SAE PAPER 872328)

The 40- by 80-foot wind tunnel circuit of the National Full-Scale Aerodynamic Complex (NFAC) has recently undergone major modifications and subsequently completed final acceptance testing. The initial testing and calibration of the wind tunnel are described and in many cases these results are compared with predictions derived from model tests and theoretical analyses. The wind tunnel meets or exceeds essentially all performance objectives. The facility runs smoothly and routinely at its maximum test-section velocity of 300 knots (Mach number = 0.45). An effective cooling air exchange system enables the wind tunnel to operate indefinitely at this maximum power condition. Throughout the operating envelope of the wind tunnel the test-section dynamic pressure is uniform to within + or - 0.5 deg, and the axial component of turbulence is generally less than 0.5 percent. Acoustic measurements indicate that, due to the low noise fans and acoustic treatment in the wind-tunnel circuit and test section, the background noise level in the test section is comparable to other large-scale acoustic wind tunnels in the United States and abroad. Author

A88-37298#
LARGE-SCALE MODEL FOR EXPERIMENTAL WIND TUNNEL INVESTIGATIONS
PETER ESCH Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 59, 60.

A 1:4.2-scale model of the Do 328 commuter airliner having a wing span of 4.75 m has been constructed from aluminum by means of NC milling techniques in order to simulate the aerodynamic characteristics of the aircraft in all flight conditions with the highest degree of fidelity. In addition to attempting to achieve identical Reynolds numbers, an effort is made to duplicate engine thrust coefficient by using pneumatically-powered engines that drive the model's two tractor propellers. The resulting model flow allows careful determination of propeller wake influence on wing aerodynamics. O.C.

A88-37907
AERODYNAMIC TESTING CONFERENCE, 15TH, SAN DIEGO, CA, MAY 18-20, 1988, TECHNICAL PAPERS
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 477 p. For individual items see A88-37908 to A88-37953.

The present conference on aerodynamic testing discusses European hypersonic testing technology, the coupling of CFD and wind tunnel test techniques, transition effects in dynamic simulation, hypersonic transition testing and prediction with magnetic suspension and balance systems, extreme altitude wind tunnel testing with magnetic suspension land balance systems, ballistic range aerothermodynamic testing, Mach 10 skin friction measurement problems, and the aerodynamic lag of a close-coupled canard aircraft model at Mach 0.3-1.6. Also discussed are three-dimensional cavity flow at transonic speeds, adaptive-wall wind tunnel research with two- and three-dimensional models, flexible wind tunnel walls for supersonic flows, scale model acoustic testing of counterrotating fans, the control system for an injector-powered transonic wind tunnel, and challenges associated with very high Reynolds number testing. O.C.

A88-37909#
A PLAN FOR COUPLING WIND TUNNEL TESTING WITH CFD TECHNIQUES
S. WEINBERG, A. LAGANELLI, A. MARTELLUCCI (Science Applications International Corp., Wayne, PA), and K. KUSHMAN (USAF, Arnold Engineering Development Center, Arnold AFB, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 12-21. refs
(Contract F40600-85-C-0002)
(AIAA PAPER 88-1996)

A plan for integrating computational fluid dynamics techniques with wind tunnel testing procedures to achieve enhanced test facility capabilities and productivity is presented and evaluated. The pretest, test and post-test elements of this WT/CFD coupling plan are identified, and the plan is applied to selected wind tunnel test programs in order to demonstrate and assess benefits. Significant advantages and cost savings are shown to result. Author

A88-37910*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE BASIC AERODYNAMICS RESEARCH TUNNEL - A FACILITY DEDICATED TO CODE VALIDATION
WILLIAM L. SELLERS, III and SCOTT O. KJELGAARD (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 22-33. refs
(AIAA PAPER 88-1997)

Computational fluid dynamics code validation requirements are discussed together with the need for close interaction between experiment and code development. Code validation experiments require a great deal of data and for the experiments to be successful, a highly-productive research facility is required. A description is provided of the NASA Langley Basic Aerodynamics Research Tunnel (BART); especially the instrumentation and experimental techniques that make the facility ideally suited to code validation experiments. Results are presented from recent tests which illustrate the techniques used in BART. Author

A88-37911*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNEXPECTED/EXPECTED RESULTS FROM THE LANGLEY 20-INCH SUPERSONIC WIND TUNNEL DURING INITIAL CHECKOUT
JAMES L. DILLON, FLOYD J. WILCOX, JR. (NASA, Langley Research Center, Hampton, VA), and ROBERT L. TRIMPI (George Washington University, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 34-42.
(AIAA PAPER 88-1999)

NASA Langley's 20-Inch Supersonic Wind Tunnel is currently undergoing shakedown tests. The facility operates over the supersonic Mach number range of 1.4 to 5.0 with Reynolds number per foot variation of approximately 500,000 to 20 million. Checkout runs have been conducted at Mach numbers of 1.4, 2.8, and 5.0 over the entire operational mass flow and total pressure envelope. Data were recorded for total temperature characteristics, Rigimesh pressure drop characteristics, and for the switching exhaust system. Data recorded and observations made during checkout are discussed. Author

A88-37912#
THE AEDC 1-FOOT TRANSONIC WIND TUNNEL - A USEFUL RESEARCH AND DEVELOPMENT FACILITY
R. L. PARKER, JR. and H. P. BLACK (Calspan Corp., Arnold AFB, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 43-48.
(AIAA PAPER 88-2001)

The USAF Arnold Engineering Development Center's 1-foot Aerodynamic Wind Tunnel is an inexpensively operated transonic wind tunnel for basic research in the Mach 0.2-1.5 range. This facility is noted to be extremely flexible in the matters of test section configuration and test installation, since it employs a three-dimensionally adaptive wall test section and variable-porosity walls. Its auxilliary systems, instrumentation capabilities, and computer facilities are comparable to larger and more sophisticated wind tunnels. O.C.

A88-37913#
DEVELOPMENT OF THE UNIVERSITY OF TEXAS AT ARLINGTON AERODYNAMICS RESEARCH CENTER
DONALD R. WILSON (Texas, University, Arlington) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 49-58. refs
(AIAA PAPER 88-2002)

An account is given of the University of Texas' test facilities for research projects concerned with aerodynamics, aerothermodynamics, and aircraft propulsion, covering the spectrum from low to hypersonic speeds. A secondary goal of these facilities is the generation of experimental data bases supporting the development and validation of CFD codes. Specific laboratory facilities encompass the Low Speed Wind Tunnel Lab, the High Speed Aerodynamics Lab's High Reynolds Number Transonic Ludwieg-Tube Wind Tunnel and Supersonic Ludwieg Tube Wind Tunnel, the Hypersonic Shock Tunnel, and the Shock Tube Facility. O.C.

A88-37914#
OPTIMUM POROSITY FOR AN INCLINED-HOLE TRANSONIC TEST SECTION WALL TREATED FOR EDGETONE NOISE REDUCTION
G. M. ELFSTROM (DSMA International, Inc., Toronto, Canada), B. MEDVED (Vazduhoplovnotehnicki Institut, Belgrade, Yugoslavia), and W. J. RAINBIRD (Carleton University, Ottawa, Canada) IN:

Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 59-64. refs
(AIAA PAPER 88-2003)

The aerodynamic wall interference properties of an inclined-hole porous wall are examined for the case where each hole has a splitter plate designed for edgetone noise attenuation. The degree of wall interference is ascertained by comparing measured cone/cylinder surface pressure signatures with those measured in the very low blockage tests carried out in the AEDC 16 ft wind tunnel, for a range of wall porosity settings, over a Mach number range of 0.6 to 1.4. In general, the present data show that low wall interference can be obtained. The optimum porosity settings are distinctly lower than those found for the AEDC 4 ft wind tunnel. Author

A88-37915#
REVIEW OF TRANSITION EFFECTS ON THE PROBLEM OF DYNAMIC SIMULATION
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 65-85. refs
(AIAA PAPER 88-2004)

Among the many problems the test engineer faces when trying to simulate full scale vehicle dynamics in a wind tunnel test is the fact that the test usually will be performed at Reynolds numbers far below those existing on the full scale vehicle. It is found that even in the case of attached flow a severe scaling problem may exist. The strong coupling existing between boundary layer transition and vehicle motion can cause the wind tunnel results to be very misleading, in some cases dangerously so. For example, the subscale test can fail to show a dynamic stability problem existing in full scale flight, or, conversely, show one that does not exist on the full scale vehicle. When flow separation occurs together with boundary layer transition, the scaling problem becomes more complicated, and the potential for dangerously misleading subscale test results increases. The existing literature is reviewed to provide examples of the different types of dynamic simulation problems that the test engineer is likely to face. Author

A88-37916#
ON HYPERSONIC TRANSITION TESTING AND PREDICTION
KENNETH F. STETSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), ELTON R. THOMPSON (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN), JOSEPH C. DONALDSON, and LEO G. SILER (Calspan Field Services, Inc., Arnold Air Force Station, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 86-93. refs
(AIAA PAPER 88-2007)

General aspects of the freestream environment and the dominant boundary-layer disturbances are discussed relative to their significance to boundary-layer transition. It is shown that the unique features of hypersonic boundary-layer transition introduce new environmental considerations for wind tunnel transition testing and transition prediction. Unlike the subsonic/supersonic situation, the boundary-layer disturbance mechanisms which influence transition of a hypersonic boundary-layer are not well known. Several potential disturbance mechanisms which could influence hypersonic transition are discussed and their possible implications regarding hypersonic transition wind tunnel testing and transition prediction. Boundary-layer stability experiments are considered essential for establishing the credibility of a hypersonic boundary-layer stability theory and the credibility of an analytical hypersonic transition prediction method. Author

A88-37917*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A REVIEW OF MAGNETIC SUSPENSION AND BALANCE SYSTEMS
RICHMOND P. BOYDEN (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 94-105. refs
(AIAA PAPER 88-2008)

This paper traces the development of Magnetic Suspension and Balance Systems (MSBSs) for use in wind tunnels. The expression MSBS implies a system that can both suspend a model and also measure the forces and moments acting on the model. This avoids the need for any mechanical support of the model. An MSBS uses electromagnets located outside the test section walls to create magnetic fields inside the test section. Measurement of the electrical current flowing in each of the electromagnets can be used to determine the forces and moments acting on the suspended model. An MSBS is capable of supporting a model with an internal magnetized core subject to gravity, aerodynamic, and inertial loads. The model must have a core made of either a permanent magnet, magnetized soft iron, or a solenoid. The position of the suspended body is inherently unstable. A closed-loop control system which includes a position sensing system has to control the position of the body by controlling the applied magnetic fields. This paper includes a discussion of all the known MSBSs and the outlook for larger systems. Author

A88-37918*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DRAG MEASUREMENTS ON A BODY OF REVOLUTION IN LANGLEY'S 13-INCH MAGNETIC SUSPENSION AND BALANCE SYSTEM
DAVID A. DRESS (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 106-116. refs
(AIAA PAPER 88-2010)

NASA Langley's 13-inch Magnetic Suspension and Balance System (MSBS) has been used to conduct low-speed wind tunnel drag force measurements on a laminar-flow body-of-revolution free of support system interference, in order to verify the drag force measurement capabilities of the MSBS. The drag force calibrations and wind-on repeatability data obtained have verified the design capabilities for this system. A drag-prediction code has been used to assess the MSBS's usefulness in body drag estimation. O.C.

A88-37920*# Old Dominion Univ., Norfolk, Va.
PROGRESS TOWARDS EXTREME ATTITUDE TESTING WITH MAGNETIC SUSPENSION AND BALANCE SYSTEMS
COLIN P. BRITCHER (Old Dominion University, Norfolk, VA) and DAVID H. PARKER IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 128-135. refs
(Contract NSG-7523; NAG1-716)
(AIAA PAPER 88-2012)

Progress is reported in a research effort aimed towards demonstration of the feasibility of suspension and aerodynamic testing of models at high angles of attack in wind tunnel Magnetic Suspension and Balance Systems. Extensive modifications, described in this paper, have been made to the Southampton University suspension system in order to facilitate this work. They include revision of electromagnet configuration, installation of all-new position sensors and expansion of control system programs. An angle of attack range of 0 to 90 deg is expected for axisymmetric models. To date, suspension up to 80 deg angle of attack has been achieved. Author

A88-37921*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A FORECAST OF NEW TEST CAPABILITIES USING MAGNETIC SUSPENSION AND BALANCE SYSTEMS
PIERCE L. LAWING and WILLIAM G. JOHNSON, JR. (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical

Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 136-144. refs
(AIAA PAPER 88-2013)

This paper outlines the potential of Magnetic Suspension and Balance System (MSBS) technology to solve existing problems related to support interference in wind tunnels. Improvement of existing test techniques and exciting new techniques are envisioned as a result of applying MSBS. These include improved data accuracy, dynamic stability testing, two-body/stores release testing, and pilot/designer-in-the-loop tests. It also discusses the use of MSBS for testing exotic configurations such as hybrid hypersonic vehicles. A new facility concept that combines features of ballistic tubes, magnetic suspension, and cryogenic tunnels is described. Author

A88-37922#
STUDY ON NEEDS FOR A MAGNETIC SUSPENSION SYSTEM OPERATING WITH A TRANSONIC WIND TUNNEL
W. R. MARTINDALE, R. W. BUTLER, and R. F. STARR, JR. (Sverdrup Technology, Inc., Arnold Air Force Station, TN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 145-150. refs
(AIAA PAPER 88-2014)

A survey of the U.S. aeronautical industry was conducted to determine if current and future transonic testing requirements are sufficient to justify continued development work on magnetic suspension and balance systems (MSBS) by NASA. The effort involved preparation of a brief technical description of magnetic balance and suspension systems, design of a survey form asking specific questions about the role of the MSBS in satisfying future testing requirements, selecting nine major aeronautical companies to which the description and survey forms were sent, and visiting the companies and discussing the survey to obtain greater insight to their response to the survey. An evaluation and discussion of the survey responses is presented. Author

A88-37926*# Syracuse Univ., N. Y.
AN ISENTROPIC COMPRESSION HEATED LUDWIEG TUBE TRANSIENT WIND TUNNEL
PATRICK J. MAGARI and JOHN E. LAGRAFF (Syracuse University, NY) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 179-188. refs
(Contract NAG3-621)
(AIAA PAPER 88-2019)

Syracuse University's Ludwieg tube with isentropic compression facility is a transient wind tunnel employing a piston drive that incorporates isentropic compression heating of the test gas located ahead of a piston. The facility is well-suited for experimental investigations concerning supersonic and subsonic vehicles over a wide range of pressures, Reynolds numbers, and temperatures; all three parameters can be almost independently controlled. Work at the facility currently includes wake-induced stagnation point heat transfer and supersonic boundary layer transition. O.C.

A88-37936*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A STUDY OF AEROELASTIC STABILITY FOR THE MODEL SUPPORT SYSTEM OF THE NATIONAL TRANSONIC FACILITY
THOMAS W. STRGANAC (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 305-310. refs
(AIAA PAPER 88-2033)

Oscillations of wind-tunnel models have been observed during testing in the National Transonic Facility. These oscillations have been the subject of an extensive investigation. As a part of this effort, a study of the aeroelastic stability of the model support structure has been performed. This structure is mathematically modelled as a wing and conventional flutter analysis is performed. The math model implemented both experimentally and numerically obtained modal characteristics. A technique for illustrating the flutter boundary for wind tunnels is demonstrated. Results indicate that the classical flutter boundary is well above the operating envelope of the facility. However, the analysis indicates a damping-dependent instability is present which is inherent in the design. One possible modification in the design has been evaluated which eliminates the predicted instability. Author

A88-37938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGHLIGHTS OF EXPERIENCE WITH A FLEXIBLE WALLED TEST SECTION IN THE NASA LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
STEPHEN W. D. WOLF and EDWARD J. RAY (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 321-330. refs
(AIAA PAPER 88-2036)

The unique combination of adaptive wall technology with a continuous flow cryogenic wind tunnel is described. This powerful combination allows wind tunnel users to carry out two-dimensional (2-D) tests at flight Reynolds numbers with wall interferences essentially eliminated. Validation testing was conducted to support this claim using well tested symmetrical and cambered airfoils at transonic speeds and high Reynolds numbers. The test section hardware has four solid walls, with the floor and ceiling flexible. The method of adapting/shaping the floor and ceiling to eliminate top and bottom wall interference at its source is outlined. Data comparisons for different size models tested and others in several sophisticated 2-D wind tunnels are made. In addition, the effects of Reynolds number, testing at high lift with associated large flexible wall movements, the uniqueness of the adapted wall shapes, and the effects of sidewall boundary layer control are examined. The 0.3-m TCT is now the most advanced 2-D research facility anywhere. Author

A88-37939*# Southampton Univ. (England).
ADAPTIVE WALL RESEARCH WITH TWO- AND THREE-DIMENSIONAL MODELS IN LOW SPEED AND TRANSONIC TUNNELS
M. C. LEWIS, G. NEAL, and M. J. GOODYER (Southampton, University, England) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 331-341. Research supported by the Department of Trade and Industry and SERC. refs
(Contract NSG-7172)
(AIAA PAPER 88-2037)

This paper summarises recent research at the University of Southampton into adaptive wall technology and outlines the direction of current efforts. The work is aimed at developing techniques for use in test sections where the top and bottom walls may be adjusted in single curvature. Wall streamlining eliminates, as far as experimentally possible, the top and bottom wall interference in low speed and transonic aerofoil testing. A streamlining technique has been developed for low speeds which allows the testing of swept wing panels in low interference environments. At higher speeds, a comparison of several two-dimensional transonic streamlining algorithms has been made and a technique for streamlining with a choked test section has also been developed. Three-dimensional work has mainly concentrated on tests of sidewall mounted half-wings and the development of the software packages required to assess interference and to adjust the flexible walls. It has been demonstrated that two-dimensional wall adaptation can significantly modify the level of wall interference around relatively large three-dimensional models. The residual interferences are small and are probably amenable to standard post-test correction methods. Tests on a calibrated wing-body model are planned in the near future to further validate the proposed streamlining technique. Author

A88-37940#
TWO-DIMENSIONAL AND THREE-DIMENSIONAL ADAPTATION AT THE T2 TRANSONIC WIND TUNNEL OF ONERA/CERT
J. P. ARCHAMBAUD and A. MIGNOSI (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 342-350. refs
(AIAA PAPER 88-2038)
The T2 transonic wind tunnel is one of the few facilities in the world working in cryogenic range (Ts=110 K - Max Reynolds number 30 M) with adaptive wall technique. The wind tunnel operates for research and production type activities since 1983. Firstly, this paper describes the T2 test section with its 2D top and bottom flexible walls and the displacement mechanism. Then, main features of the 2D adaptation strategy are explained, and results on airfoils are presented. Finally, the 3D adaptation strategy is developed and test results with symmetrical bodies and half wings are presented. Author

A88-37941#
ADAPTATION OF FLEXIBLE WIND TUNNEL WALLS FOR SUPERSONIC FLOWS
S. L. RILL and U. GANZER (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 351-356. BMFT-sponsored research.
(AIAA PAPER 88-2039)
Adaptive walls are supposed to reduce or possibly eliminate wall interferences in wind tunnels. A recent topic of research in the field of adaptive wall technique at TU-Berlin has been the extension of the adaptation procedure to flows at high subsonic and low supersonic Mach numbers. In this paper a detailed description of the concept of supersonic wall adaptation together with first experimental results obtained in the octagonal test section is presented. A numerical simulation of the supersonic adaptation is used to study the convergence behavior and the influence of the jack spacing on the residual interferences. Author

A88-37942#
THE RESEARCH ON ADAPTIVE WALL WIND TUNNEL IN NORTHWESTERN POLYTECHNICAL UNIVERSITY OF CHINA
JIA JU HE and PEI CHU ZUO (Northwestern Polytechnical University, Xian, People's Republic of China) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 357-362. refs
(AIAA PAPER 88-2040)
An evaluation is made of the last five years' progress with adaptive wall test section-incorporating wind tunnel designs in a major Chinese research facility, at the Northwestern Polytechnical University of China. Attention is given to the working principles of two adaptive-wall wind tunnel types investigated, the numerical simulation of such wind tunnels, the design of a flexible-wall self-streamlining test section, and the results of a program of iterative testing involving a method for convergent velocity acceleration. O.C.

A88-37943#
THE USE OF 2-D ADAPTIVE WALL TEST SECTIONS FOR 3-D FLOWS
E. WEDEMEYER (DFVLR, Goettingen, Federal Republic of Germany) and L. LAMARCHE (Montreal, Universite, Montreal, Canada) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 363-371. refs
(AIAA PAPER 88-2041)
A method for the use of adaptive wall wind tunnel test sections with two flexible walls for the testing of three-dimensional models, first proposed by Wedemeyer in 1982, has been elaborated and verified by means of both numerical and experimental tests. Attention is presently given to the results of the application of a linear and a nonlinear adaptation procedure, as revealed by numerical and experimental trials. For a typical aircraft wind tunnel model in a square test section with 70-percent span/tunnel width ratio, the wall-induced upwash at the wing tips is reduced to 25 percent of its original value. The wall adaptation procedure is simple and requires little computational effort so long as the wall equations can be linearized. O.C.

A88-37944*# Sandia National Labs., Albuquerque, N. Mex.
HEATING REQUIREMENTS AND NONADIABATIC SURFACE EFFECTS FOR A MODEL IN THE NTF CRYOGENIC WIND TUNNEL
J. M. MACHA, D. B. LANDRUM (Sandia National Laboratories, Albuquerque, NM), L. A. PARE, III (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and C. B. JOHNSON (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 372-381. refs
(Contract NAG1-417)
(AIAA PAPER 88-2044)
A theoretical study has been made of the severity of nonadiabatic surface conditions arising from internal heat sources within a model in a cryogenic wind tunnel. Local surface heating is recognized as having an effect on the development of the boundary layer, which can introduce changes in the flow about the model and affect the wind tunnel data. The geometry was based on the NTF Pathfinder I wind tunnel model. A finite element heat transfer computer code was developed and used to compute the steady state temperature distribution within the body of the model, from which the surface temperature distribution was extracted. Particular three dimensional characteristics of the model were represented with various axisymmetric approximations of the geometry. This analysis identified regions on the surface of the model susceptible to surface heating and the magnitude of the respective surface temperatures. It was found that severe surface heating may occur in particular instances, but could be alleviated with adequate insulating material. The heat flux through the surface of the model was integrated to determine the net heat required to maintain the instrumentation cavity at the prescribed temperature. The influence of the nonadiabatic condition on boundary layer properties and on the validity of the wind tunnel simulation was also investigated. Author

A88-37945*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A FLOW-TRANSFER DEVICE WITH NONMETALLIC DIAPHRAGMS FOR PROPULSION WIND TUNNEL MODELS
FRANCIS J. CAPONE and BARRY L. PRICE (NASA, Langley Research Center, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 382-391. refs
(AIAA PAPER 88-2048)
The Langley Research Center has developed a new flow-transfer device for powered wind tunnel models in which the traditional metal bellows have been replaced with nonmetallic diaphragms. Two complete flow transfer assemblies have been fabricated and installed within a twin-jet propulsion simulation system. Calibrations of the force balance have been performed over a range of nozzle mass flow rates up to 15 lbs/sec in order to validate the nonmetallic diaphragm design concept. Results from these calibrations are compared to those obtained with flow-transfer devices utilizing metal bellows. Author

A88-37946#
MACH NUMBER CORRECTIONS FOR A TWO-FOOT PROPELLER RIG IN SOLID AND SLOTTED TEST SECTIONS
A. J. KRYNYTZKY (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American

Institute of Aeronautics and Astronautics, 1988, p. 392-401. refs
(AIAA PAPER 88-2056)

A 2-ft diameter contrarotating propfan of a type under consideration for noise-critical commercial aircraft applications has been wind tunnel tested in both acoustic (solid-walled) and slotted test sections at Mach of up to 0.83. A combination of experimental and theoretical techniques is used to develop a flight-equivalent test Mach number, including corrections for solid blockage, support interference, and thrust interference. The use of wall-mounted static pressure rails is noted to be indispensable in correlating Mach number in the two test sections. O.C.

A88-37949#

MICROPROCESSOR CONTROL OF HIGH-SPEED WIND TUNNEL STAGNATION PRESSURE

Y.-T. FUNG, G. S. SETTLES, and A. RAY (Pennsylvania State University, University Park) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 429-435. refs
(Contract AF-AFOSR-84-0184)
(AIAA PAPER 88-2062)

The development and implementation of a control algorithm for the microprocessor-based stagnation pressure control system of the Penn State Supersonic Wind Tunnel Facility is reported. The gas dynamics and the control-valve characteristics of this blowdown-type facility are nonlinearly related. A mathematical model was developed for the open-loop system characteristics and was linearized for the controller design. A single-input, single-output PI controller was chosen for this task because of its simplicity and availability. The resulting performance of the supersonic wind tunnel was found to be quite good, with stagnation pressure variations typically held to within 1 to 2 percent. Author

A88-37950#

DEVELOPMENT OF A CONTROL SYSTEM FOR AN INJECTOR POWERED TRANSONIC WIND TUNNEL

D. F. LONG and K. S. GLADEN (Fluidyne Engineering Corp., Minneapolis, MN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 436-445. refs
(AIAA PAPER 88-2063)

A mathematical model of the FFA T1500 Injector Driven Transonic Wind Tunnel is developed. The tunnel process is simulated by solving the equations of one-dimensional gas dynamics. These are modified where appropriate to simulate the operation of the injector, circuit exhaust, test section plenum and the choke control system downstream of the test section. The algorithms which control the valve actuation rates are described. Results are presented which show that the control system is able to stabilize the tunnel flow and that the startup time from rest to stable flow is on the order of four seconds. Author

A88-38169

WIND TUNNEL INTERFERENCE ON UNSTEADY TWO-DIMENSIONAL AEROFOIL MOTIONS IN LOW SPEED FLOWS

C. W. CHEUNG and G. J. HANCOCK (Queen Mary College, London, England) Aeronautical Journal (ISSN 0001-9240), vol. 92, March 1988, p. 115-121.

The aerodynamic characteristics of two-dimensional transient aerofoil motions in low-speed flows in a wind tunnel with either closed wall or open (jet) walls, including the effect of a downstream closed wall diffuser, have been investigated. The mathematical formulation for the aerofoil and its unsteady wake is based on linear theory and is solved by a piecewise linear vorticity method; the wall boundaries are represented by distributions of sources. Numerical calculations have been made for various values of tunnel height to chord ratio. Interference effects on the rate of build up of lift to a steady state following a step change in incidence can be large, especially for open jet tunnels. Author

A88-38692*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

USE OF DYNAMICALLY SCALED MODELS FOR STUDIES OF THE HIGH-ANGLE-OF-ATTACK BEHAVIOR OF AIRPLANES

JOSEPH R. CHAMBERS (NASA, Langley Research Center, Hampton, VA) International Symposium on Scale Modeling, Tokyo, Japan, July 18-22, 1988, Paper. 11 p. refs

Dynamically scaled, free-flying models are used by NASA to study the stalling and spinning characteristics of civil and military airplane configurations. Such tests have been conducted for many different designs, and it has been possible to correlate the results predicted by the model tests with flight test results obtained in the investigations. The present paper describes four of the dynamic model testing techniques used at the NASA Langley Research Center, including the scaling laws used in the construction of models and in the interpretation of results. Predictions of stall/spin behavior based on model results have generally been very accurate, and the model tests are regarded as an invaluable precursor to full-scale flight tests. However, aerodynamic scale effects between some models and full-scale airplanes due to differences in test values of Reynolds number have resulted in erroneous predictions for a few configurations. A discussion of these effects is provided, together with the approach used to modify the model so that its behavior more closely matches that of the airplane. Finally, two typical applications of the techniques to the X-29A research airplane and several general aviation research airplanes are presented to illustrate the type of information provided by the tests. Author

A88-38711*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

THE NASA INTEGRATED TEST FACILITY AND ITS IMPACT ON FLIGHT RESEARCH

D. A. MACKALL, M. D. PICKETT, L. J. SCHILLING, and C. A. WAGNER (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 85-97. refs
(AIAA PAPER 88-2095)

NASA-Ames' Integrated Test Facility (ITF), when completed, will provide ground test facilities for the safe and efficient testing of advanced research aircraft with fully integrated flight control, propulsion systems, structures, and aerodynamic configurations. Flight test risk will be minimized through the reduction of differences between flight and ground test environments; the latter will involve the interfacing of real-time flight simulation with the actual aircraft through a simulation-interface device. The test process and the collection and management of test data will be automated. Attention is given to preliminary ITF results for the X-29 aircraft. O.C.

A88-38712*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

DEVELOPMENT OF AN INTEGRATED SET OF RESEARCH FACILITIES FOR THE SUPPORT OF RESEARCH FLIGHT TEST

ARCHIE L. MOORE and CONSTANCE D. HARNEY (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 98-111. refs
(AIAA PAPER 88-2096)

The Ames-Dryden Flight Research Facility (DFRF) serves as the site for the conduct of high-risk flight research on many one-of-a-kind test vehicles like the X-29A advanced technology demonstrator, F-16 advanced fighter technology integration (AFTI), AFTI F-111 mission adaptive wing, and F-18 high-alpha research vehicle (HARV). Ames-Dryden is on a section of the historic Muroc Range. The facility is oriented toward the testing of high-performance aircraft, as shown by its part in the development of the X-series aircraft. Given the cost of research flight test and the complexity of today's systems-driven aircraft, an integrated set of ground support experimental facilities is a necessity. In support of the research flight test of highly advanced test beds, the DFRF is developing a network of facilities to expedite the acquisition and distribution of flight research data to the researcher.

This network consists of an array of experimental ground-based facilities and systems as nodes and the necessary telecommunications paths to pass research data and information between these facilities. This paper presents a status of the current network, an overview of current developments, and a prospectus on future major enhancements. Author

A88-38713#

USING GPS TO ENHANCE THE DT&E RANGES

THOMAS P. HANCOCK (USAF, Washington, DC) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 112-117.

(AIAA PAPER 88-2098)

GPS flight test range instrumentation will yield very precise target position indications, allow mobile land/sea ranges to be established without presurvey, extend existing ranges over their current horizons, and establish a world-wide common grid system facilitating interrange operations. Attention is presently given to the characteristics of the data link and range system, the solid state recorder employed, the translator-translator processor concept and design, the treatment of ground transmitters as 'pseudosatellites', and the results of efforts to integrate each of the demonstration ranges. O.C.

A88-38740#

FLIGHT TESTING AT THE WEST COAST OFFSHORE OPERATING AREA

DALE A. DOTY, STANLEY K. GAROUTTE, and ERNIE R. SNOWDON (ITT Federal Electric Corp., Vandenberg AFB, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 343-350.

(AIAA PAPER 88-2150)

The USAF's West Coast Offshore Operating Area (WCOOA) stretches off the California coast from Point Conception in the south to 44 deg N. In addition to possessing overlapping coverage from Air Route Surveillance Radars, users can make use of both the Western Test Range and U.S. Navy Pacific Missile Test Center. Under normal weather conditions, flights are conducted in a virtually isothermal environment. Favorable conditions exist for hazardous activities throughout WCOOA, due to the empty ocean over which flights are conducted. O.C.

A88-38744*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

DEVELOPMENT OF AN INTERACTIVE REAL-TIME GRAPHICS SYSTEM FOR THE DISPLAY OF VEHICLE SPACE POSITIONING

ROBERT COMPERINI (Datamax Computer Systems, Inc., Edwards, CA) and DONALD C. RHEA (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 376-387.

(AIAA PAPER 88-2167)

This paper will outline a new approach taken by the NASA Western Aeronautical Test Range to display real-time space positioning data using computer-generated images that produce a graphic representation of an area map integrated with the research flight test aircraft track. This display system supports research flight test requirements of research projects such as the advanced fighter technology integration (AFTI) F-16, F-18 high alpha research vehicle (HARV), AFTI F-111 mission adaptive wing (MAW), F-15, and X-29A forward-swept wing. This paper will discuss the requirements, system configuration and capability, and future system applications. Author

A88-38745*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

THE PC/AT COMPATIBLE COMPUTER AS A MISSION CONTROL CENTER DISPLAY PROCESSOR AT AMES-DRYDEN FLIGHT RESEARCH FACILITY

KEVIN R. HAMMONS (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 388-405. refs

(AIAA PAPER 88-2168)

The NASA Ames-Dryden Flight Research Facility's Western Aeronautical Test Range will assign the flight test data display processing function to Mission Control Centers in order to allow research engineers to flexibly configure their own display-processing system to optimize performance during a flight research mission. This will leave the Telemetry Radar Acquisition and Processing System more time to acquire data. One of the processors chosen to handle the display-processing function is an IBM PC/AT-compatible, rack-mounted PC giving engineers a personalized set of analytic and display tools, developed on the basis of off-the-shelf PC/AT-compatible engineering hardware and software items. O.C.

A88-38761*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

DEVELOPMENT OF A MOBILE RESEARCH FLIGHT TEST SUPPORT CAPABILITY

DONALD C. RHEA and ARCHIE L. MOORE (NASA, Flight Research Center, Edwards, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 520-528.

(AIAA PAPER 88-2087)

This paper presents the approach taken by the NASA Western Aeronautical Test Range (WATR) of the Ames Research Center (ARC) to develop and utilize mobile systems to satisfy unique real-time research flight test requirements of research projects such as the advanced fighter technology integration (AFTI) F-16, YAV-8B Harrier, F-18 high-alpha research vehicle (HARV), XV-15, and the UH-60 Black Hawk. The approach taken is cost-effective, staff efficient, technologically current, and provides a safe and effective research flight test environment to support a highly complex set of real-time requirements including the areas of tracking and data acquisition, communications (audio and video) and real-time processing and display, postmission processing, and command uplink. The development of this capability has been in response to the need for rapid deployment at varied site locations with full real-time comutation and display capability. This paper will discuss the requirements, implementation and growth plan for mobile systems development within the NASA Western Aeronautical Test Range. Author

A88-39525#

THE INTEGRATION OF WIND TUNNEL AND WATER TUNNEL RESULTS FOR A NEW IN-FLIGHT SIMULATOR CONFIGURATION

DENNIS L. CARTER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988. 13 p.

(AIAA PAPER 88-2045)

A series of wind tunnel and water tunnel tests have been conducted to study the generation of direct sideforce for the VISTA (Variable Stability In-Flight Simulator Test Aircraft). The studies involved low-speed wind tunnel and water tunnel tests of vertical fins mounted on the wing of an F-16 aircraft at various span stations. Results showed that the vortex coming from the strake can be utilized to generate significant levels of direct sideforce over most of the usable angle of attack range. Author

A88-40066

VEHICLES AND AIRCRAFT ON FLOATING ICE

V. A. SQUIRE, P. J. LANGHORNE (Otago, University, Dunedin, New Zealand), W. H. ROBINSON, and T. G. HASKELL (Department of Scientific and Industrial Research, Lower Hutt, New Zealand) Nature (ISSN 0028-0836), vol. 333, May 12, 1988, p. 159-161. Research supported by the New Zealand Ross Dependency Research Committee, University of Cambridge, Royal Society of London, and Trans-Antarctic Association. refs

Some preliminary results are reported from a new and complete set of experiments done on Antarctic sea ice using strain gages to measure directly the strain induced in the ice by vehicles driving over it. The experimental vehicles were an extended cab pickup truck weighing 2100 kg and an LC-130 Hercules aircraft weighing some 50,000 kg. The results show excellent agreement in all respects with theoretical calculations of the deflection profile due to moving loads. C.D.

A88-40721*# Vigyan Research Associates, Inc., Hampton, Va.
A PANEL METHOD PROCEDURE FOR INTERFERENCE ASSESSMENT IN SLOTTED-WALL WIND TUNNELS
WILLIAM B. KEMP, JR. (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 185-193. refs
(Contract NAS1-17919; NASA TASK 32)
(AIAA PAPER 88-2537)

This paper describes a method for three-dimensional wind tunnel interference assessment developed specifically for slotted-wall tunnels. The method is an adaptation to the assessment problem of a previously published high-order panel method procedure for simulating the flow in slotted-wall tunnel test sections. The method uses a mixed outer boundary condition, primarily a Neumann condition, with measured pressure constraints used to control only those boundary phenomena which can not be specified accurately a priori. Assessment results are illustrated from a calibration test with variations in wall geometry, and from tests of a generic subsonic transport aircraft configuration. Author

A88-40722*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A TRANSONIC WIND TUNNEL WALL INTERFERENCE PREDICTION CODE
PAMELA S. PHILLIPS and EDGAR G. WAGGONER (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 194-203. refs
(AIAA PAPER 88-2538)

A small disturbance transonic wall interference prediction code has been developed that is capable of modeling solid, open, perforated, and slotted walls as well as slotted and solid walls with viscous effects. This code was developed by modifying the outer boundary conditions of an existing aerodynamic wing-body-pod-pylon-winglet analysis code. The boundary conditions are presented in the form of equations which simulate the flow at the wall, as well as finite difference approximations to the equations. Comparisons are presented at transonic flow conditions between computational results and experimental data for a wing alone in a solid wall wind tunnel and wing-body configurations in both slotted and solid wind tunnels. Author

A88-40723*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DIRECT ASSESSMENT OF TWO-DIMENSIONAL WIND-TUNNEL INTERFERENCE FROM MEASUREMENTS ON TWO INTERFACES
CHING F. LO (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 204-207. refs
(AIAA PAPER 88-2539)

A direct assessment of two-dimensional wind-tunnel wall interference using upwash component measured on two interfaces has been formulated by the Prandtl-Glauert equation of the flow field and solved by the Fourier transform technique. The analytic formulae obtained for the interference of upwash and pressure on the model are presented. The formulae have been applied successfully to the analytic models for lifting and blockage interferences induced by the general linear slotted and perforated tunnel wall boundary conditions. The formulae have been derived in terms of Fourier coefficients of the measured upwash and illustrated its merits applying to a wavy-wall model case. Author

N88-22043# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
GEOMETRIC MODELING OF FLIGHT INFORMATION FOR GRAPHICAL COCKPIT DISPLAY M.S. Thesis
MARK A. KANKO Dec. 1987 120 p Original contains color illustrations
(AD-A190484; AFIT/GCE/ENG/87D-6) Avail: NTIS HC A06/MF A01 CSCL 01D

The purpose of this thesis was to design and implement a graphics-based environment capable of modeling tactical situation arenas as viewed from the cockpit. The modeled region was composed of mountains, hostile threat envelopes, and a projected flightpath through the region. Resulting displays were to be used in the Microprocessor-Based Application of Graphics Interactive Communication (MAGIC) cockpit owned by the Crew Systems Development Branch within the USAF FDL at Wright-Patterson. This cockpit is used to prototype new graphical display formats that might be used in future aircraft. The individual 3-D objects used to represent threats and mountains in the model were generated by geometric procedural models. A strongly-parameterized procedural model would generate a three-dimensional surface of revolution composed of polygons from a 2-D profile input by the user. Once defined, each object could then be instantiated into the model representing the complete tactical situation. Positioning of objects in the model was accomplished via a mouse input device. The implemented data representation allowed the model to be easily modifiable. An overall goal was to allow the cockpit display researcher to create an entirely new tactical situation display model in less than one hour. GRA

N88-22044# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MULTIPLE MODEL PARAMETER ADAPTIVE CONTROL FOR IN-FLIGHT SIMULATION M.S. Thesis
THOMAS J. BERENS Mar. 1988 88 p
(AD-A190568; AFIT/GE/ENG/88M-3) Avail: NTIS HC A05/MF A01 CSCL 01D

Adaptive control of aircraft model-following systems has shown promising results for in-flight simulation, but the computational expense and slow convergence of conventional parameter estimation techniques for higher order models inhibits their direct use for in-flight simulation. Computer simulations of adaptive systems usually assume some knowledge of model parameters in order to maintain tracking fidelity at a reasonable computational cost as parameters change. This thesis incorporates apriori information into a multiple-model estimation algorithm which assigns a probability weighting of each estimator within a bank of estimators. Final parameter estimates used in adaptive control are formed as a probabalistic weighted sum of individual estimates. Simulations of the system show excellent tracking performance throughout the flight envelope. A moving bank scheme for use over a wide range of flight conditions is recommended as a further area of study. GRA

N88-22045*# Stanford Univ., Calif. Joint Inst. for Aeronautics and Acoustics.
CONTRACTION DESIGN FOR SMALL LOW-SPEED WIND TUNNELS
JAMES H. BELL and RABINDRA D. MEHTA Apr. 1988 37 p
(Contract NCC2-294)
(NASA-CR-182747; NAS 1.26:182747; JIAA-TR-84) Avail: NTIS HC A03/MF A01 CSCL 14B

An iterative design procedure was developed for 2- or 3-dimensional contractions installed on small, low speed wind tunnels. The procedure consists of first computing the potential flow field and hence the pressure distributions along the walls of a contraction of given size and shape using a 3-dimensional numerical panel method. The pressure or velocity distributions are then fed into 2-dimensional boundary layer codes to predict the behavior of the boundary layers along the walls. For small, low speed contractions, it is shown that the assumption of a laminar boundary layer originating from stagnation conditions at the contraction entry and remaining laminar throughout passage through the successful designs is justified. This hypothesis was confirmed by comparing the predicted boundary layer data at the contraction exit with measured data in existing wind tunnels. The measured boundary layer momentum thicknesses at the exit of four existing contractions, two of which were 3-D, were found to lie within 10 percent of the predicted values, with the predicted values generally lower. From the contraction wall shapes investigated, the one based on a 5th order polynomial was selected for newly designed mixing wind tunnel installation. Author

N88-22046# Oak Ridge National Lab., Tenn.
INVESTIGATION OF AEROACOUSTIC MECHANISMS BY REMOTE THERMAL IMAGING
A. J. WITTEN and G. E. COURVILLE 1988 15 p Presented at the 10th Thermosense Conference, Orlando, Fla., 4 Apr. 1988
(Contract DE-AC05-84OR-21400)
(DE88-002612; CONF-880461-1) Avail: NTIS HC A03/MF A01

A hush house is a hangar-like structure designed to isolate, from the surrounding environment, the noise produced by extended aircraft engine operations during testing. While hush houses meet this intended need by suppressing audible noise, they do emit significant subaudible acoustic energy causing structural vibrations in nearby facilities. As a first step in mitigating the problems associated with hush house induced vibrations, it is necessary to identify the mechanism responsible for the low frequency acoustic emissions. It was hypothesized that the low frequency acoustic waves are a result of acoustic Cherenkov radiation. This radiation is in the form of a coherent wave produced by the engine exhaust gas flow. The speed of sound in the exhaust gas is quite high as a result of its elevated temperature. Therefore, the gas flow is sonic or subsonic relative to its own sound speed, but is supersonic relative to sound speed in the surrounding cooler air and, as a result, produces acoustic Cherenkov radiation. To confirm this hypothesis, thermographic surveys were conducted to image the thermal structure of the engine exhaust gas within the hush house. In the near field, these images revealed that the exhaust gases did not behave like a high Reynolds number turbulent jet, but rather, the transition to turbulence is delayed by a suppression in growth of the self-excited instability wave as a result of acoustic Cherenkov radiation. DOE

N88-22047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MODIFICATIONS TO THE LANGLEY 8-FOOT TRANSONIC PRESSURE TUNNEL FOR THE LAMINAR FLOW CONTROL EXPERIMENT
CHARLES D. HARRIS and CUYLER W. BROOKS, JR. May 1988 123 p
(NASA-TM-4032; L-16387; NAS 1.15:4032) Avail: NTIS HC A06/MF A01 CSCL 14B

Modifications to the NASA Langley 8 Foot Transonic Pressure Tunnel in support of the Lamina Flow Control (LFC) Experiment included the installation of a honeymoon and five screens in the settling chamber upstream of the test section 41-long test section liner that extended from the upstream end of the test section contraction region, through the best section, and into the diffuser. The honeycomb and screens were installed as permanent additions to the facility, and the liner was a temporary addition to be removed at the conclusion of the LFC Experiment. These modifications are briefly described. Author

N88-22048# National Bureau of Standards, Boulder, Colo. Electromagnetic Fields Div.
EMR (ELECTROMAGNETIC RADIATION) TEST FACILITIES EVALUATION OF REVERBERATING CHAMBER LOCATED AT RADC (ROME AIR DEVELOPMENT CENTER), GRIFFISS AFB (AIR FORCE BASE), ROME, NEW YORK
M. L. CRAWFORD, G. H. KOEPKE, and J. M. LADBURY Dec. 1987 78 p Sponsored by RADC, Griffiss AFB, N.Y.
(PB88-178827; NBSIR-87/3080) Avail: NTIS HC A05/MF A01 CSCL 14B

The report describes measurement procedures and results obtained from evaluating the reverberating chamber facility located at the Rome Air Development Center (RADC), Griffiss Air Force Base, Rome, New York. The facility was developed by the RADC for use in measuring and analyzing the electromagnetic susceptibility/vulnerability (EMS/V) of weapon systems and the shielding effectiveness of enclosures and shielding materials. A brief description of the facility, including the instrumentation used for performing its evaluation and calibration by the National Bureau of Standards (NBS) is given. GRA

N88-22049# National Telecommunications and Information Administration, Boulder, Colo. Inst. for Telecommunication Sciences.
INVESTIGATIONS OF TEST METHODOLOGY FOR THE STRESS LOADING FACILITY
R. D. JENNINGS Sep. 1987 188 p Sponsored by Army Electronic Proving Ground, Fort Huachuca, Ariz.
(PB88-166095; NTIA-87-228) Avail: NTIS HC A09/MF A01 CSCL 14B

The U.S. Army Electronic Proving Ground (USAEPG) is planning the development of a new test facility to be known as the Stress Loading Facility (SLF). The facility is envisioned as an integrated and automated test capability that will generate a dense electromagnetic threat test environment and simultaneously monitor key performance parameters of a system being tested. The report reviews current test capabilities that are relevant to the SLF, both within and outside of USAEPG, and develops test methodologies for the SLF. GRA

N88-22050*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
REAL-TIME FLIGHT TEST DATA DISTRIBUTION AND DISPLAY
MICHAEL C. NESEL and KEVIN R. HAMMONS May 1988 11 p Presented at the 4th Flight Test Conference, San Diego, Calif., 18-20 May 1988
(NASA-TM-100424; H-1454; NAS 1.15:100424; REPT-314-50; REPT-314-60; AIAA-88-2216) Avail: NTIS HC A03/MF A01 CSCL 14B

Enhancements to the real-time processing and display systems of the NASA Western Aeronautical Test Range are described. Display processing has been moved out of the telemetry and radar acquisition processing systems super-minicomputers into user/client interactive graphic workstations. Real-time data is provided to the workstations by way of Ethernet. Future enhancement plans include use of fiber optic cable to replace the Ethernet. Author

N88-22907# Sandia National Labs., Albuquerque, N. Mex.
ULTRASONIC TIME-OF-FLIGHT DIFFRACTION (TOFD) MEASUREMENTS OF CRACK DEPTHS IN AN ACCELERATION RESERVOIR OF A HIGH VELOCITY RESEARCH GUN
J. H. GIESKE 1988 17 p Presented at the 30th Meeting of the Weapons Agencies Nondestructive Testing Organization (WANTO), Largo, Fla., 12 Jan. 1988
(Contract DE-AC04-76DP-00789)
(DE88-006644; SAND-88-0376C; CONF-880160-4) Avail: NTIS HC A03/MF A01

The Acceleration Reservoir (AR) of a two-stage light gas gun at Sandia's STAR - Shockwave Thermodynamic Applied Research - facility allows for the formation of shock fronts to propagate and accelerate projectiles with impact velocities up to 25,000 ft/second. The shock loading techniques are used by the Thermomechanical and Physical Division 1534 to study the properties of materials under extreme stress, stress rate, and temperature conditions. Because of the impact of a lead slurry-impregnated polyethylene piston at the tapered section of the AR, fatigue cracks develop and propagate in the bore area after each shot of the gun. Presently, the AR is taken out of service when the outer diameter of the AR increases by a given amount. In order to learn more about the actual damage present in a retired AR, the present study was undertaken. The reservoir investigated in this study was taken out of service after 103 shots. The ultrasonic pulse echo and Time-Of-Flight Diffraction (TOFD) techniques were employed in order to quantify the distribution of cracks along with their lengths and depths. The ultrasonic data will be used by division 1534 to investigate the nature of the fracturing process and perhaps model with a computer the dynamics of a crack subjected to pulse and shock loading. Hopefully, this information may then be used in the future to determine the proper retirement time of the reservoir. DOE

N88-22909# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Hauptabteilung Windkandele.
THE TRANSONIC WIND TUNNEL (TWB) AT DFVLR, BRUNSWICK (FEDERAL REPUBLIC OF GERMANY) Status Report, 1987
WOLFGANG PUFFERT-MEISSNER Dec. 1987 47 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1114) Original contains color illustrations (DFVLR-MITT-88-01; ISSN-0176-7739; ETN-88-92317) Avail: NTIS HC A03/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany, 30.50 DM

The transonic wind tunnel Braunschweig is a pressurized blowdown windtunnel. The test section for two-dimensional airfoil testing has an area of 0.34 x 0.60 m. Mach number range is from 0.3 to 0.95 and Reynolds number range from 2,900,000 to 12 million at Mach 0.7, based on an airfoil chord length of 150 mm. Information required for the preliminary planning of test programs and for preliminary layout of models used in such programs is given. ESA

N88-22911*# National Aeronautics and Space Administration, Washington, D.C.
FLOW QUALITY OF NAL TWO-DIMENSIONAL TRANSONIC WIND TUNNEL. PART 1: MACH NUMBER DISTRIBUTIONS, FLOW ANGULARITIES AND PRELIMINARY STUDY OF SIDE WALL BOUNDARY LAYER SUCTION
SEIZO SAKAKIBARA, KAZUAKI TAKASHIMA, HITOSHI MIWA, YASUO OGUNI, MAMORU SATO, and HIROSHI KANDA May 1988 96 p Transl. into ENGLISH of Japanese report (Tokyo, Japan, National Aerospace Lab.), 1982 p 1-79 Original language document was announced as N83-12043 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4307)
(NASA-TT-20209; NAS 1.77:20209; NAL-TR-693) Avail: NTIS HC A05/MF A01 CSCL 14B

Experimental data on the flow quality of the National Aerospace Laboratory two-dimensional transonic wind tunnel are presented. Mach number distributions on the test section axis show good uniformity which is characterized by the two sigma (standard deviation) values of 0.0003 to 0.001 for a range of Mach numbers from 0.4 to 1.0. Flow angularities, which were measured by using a wing model with a symmetrical cross section, remained within 0.04 deg for Mach numbers from 0.2 to 0.8. Side wall boundary layer suction was applied through a pair of porous plates. The variation of aerodynamic properties of the model due to the suction mass flow rate change is presented with a brief discussion. Two dimensionality of the flow over the wing span is expected to be improved by applying the appropriate suction rate, which depends on the Mach number, Reynolds number, and lift coefficient. Author

N88-22912# Universal Energy Systems, Inc., Dayton, Ohio.
SOFT-GROUND AIRCRAFT ARRESTING SYSTEMS Final Report, Sep. 1986 - Aug. 1987
ROBERT F. COOK Aug. 1987 142 p
(Contract F33615-86-D-3800)
(AD-A190838; DOT/FAA/PM-87/27) Avail: NTIS HC A07/MF A01 CSCL 01E

The soft-ground aircraft arresting system study was initiated to determine whether or not aircraft having gross weight of 114,000 pounds to 630,000 pounds could be safely stopped after overrunning the available length of runway. The extended length of runway was limited to 1000 feet and the maximum velocity of the overrunning aircraft was selected to be 70 knots. The system was to be completely passive, have a long life, and easily repaired and maintained. Several arrestor materials such as clay, sand, gravel, water, an plastic foam were considered. An aircraft wheel/arrestor material model was developed and incorporated into a computer program FITER which allowed the determination of the aircraft stopping distance, landing gear loads, dynamic response, and rut depth in the arrestor material. Analyses conducted showed that sand, clay and water systems were not suitable arresting materials. Aircraft arrestment simulations were conducted for gravel and plastic foam arrestors and it was found that all aircraft could be safely stopped in less than 1000 feet. Evaluation of the stopping distance in an arrestor bed with the stopping distance of an extended runway was made and it was found that the arrestor system was needed to assure the safe stopping of an aircraft. GRA

N88-23126*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WATER FACILITIES IN RETROSPECT AND PROSPECT: AN ILLUMINATING TOOL FOR VEHICLE DESIGN
GARY E. ERICKSON, DAVID J. PEAKE, JOHN DELFRATE, ANDREW M. SKOW, and GERALD N. MALCOLM (Eidetics International, Inc., Torrance, Calif.) *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 28 p Jun. 1987 Previously announced as N87-13403
Avail: NTIS HC A20/MF A01 CSCL 14B

Water facilities play a fundamental role in the design of air, ground, and marine vehicles by providing a qualitative, and sometimes quantitative, description of complex flow phenomena. Water tunnels, channels, and tow tanks used as flow-diagnostic tools have experienced a renaissance in recent years in response to the increased complexity of designs suitable for advanced technology vehicles. These vehicles are frequently characterized by large regions of steady and unsteady 3-D flow separation and ensuing vortical flows. The visualization and interpretation of the complicated fluid motions about isolated vehicle components and complete configurations in a time and cost effective manner in hydrodynamic test facilities is a key element in the development of flow control concepts, and, hence, improved vehicle designs. A historical perspective of the role of water facilities in the vehicle design process is presented. The application of water facilities to specific aerodynamic and hydrodynamic flow problems is discussed, and the strengths and limitations of these important experimental tools are emphasized. Author

N88-23128# Societe Bertin et Cie, Plaisir (France).
QUALIFICATION OF A WATER TUNNEL FOR FORCE MEASUREMENTS ON AERONAUTICAL MODELS [QUALIFICATION DUN TUNNEL HYDRODYNAMIQUE POUR DES PESEES DE MAQUETTES AERONAUTIQUES]
B. CHEZLEPRETRE and Y. BROCARD *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 15 p Jun. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A20/MF A01

Bertin and Company maintains a water tunnel where flow visualization, and velocity and force measurements are performed. Recently, force measurements were done on a wing-canard model which was also tested in a wind tunnel at ONERA. This paper focuses on the presentation of the facility (including its laser anemometer and the computerized data acquisition system) and on the satisfactory comparison of the balance measurements obtained in both water and wind tunnels. Author

N88-23132# National Research Council of Canada, Ottawa (Ontario). Low Speed Aerodynamics Lab.
THE USE OF THE NRC/NAE WATER FACILITIES IN CANADIAN AERONAUTICAL RESEARCH AND DEVELOPMENT
R. H. WICKENS and N. E. JEFFREYS *In* AGARD, Aerodynamic

and Related Hydrodynamic Studies Using Water Facilities 20 p Jun. 1987
Avail: NTIS HC A20/MF A01

Described are some of the hydrodynamic facilities of the National Research Council in Ottawa and St. John's, Newfoundland. The NAE water tunnel, in particular, contributed to the understanding of the aerodynamics of various VSTOL concepts, and complex flows containing strong elements of vorticity and unsteadiness. Several projects are described in which fundamental flow observations were made, and from which data was obtained in support of theoretical investigations. The past and future potential of several water facilities of the NRC for pursuing aeronautical and marine research are described. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A88-39419#
TECHNOLOGIES FOR HYPERSONIC FLIGHT
ECKART STEINHEIL and WOLFGANG UHSE Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 45-48.

An account is given of the technology readiness requirements of the West German Saenger II air-breathing first-stage, two-stage reusable launcher system. The present, five-year conceptual development phase will give attention to propulsion, aerothermodynamic, materials/structures, and flight guidance technology development requirements. The second, seven-year development phase will involve other West European design establishments and lead to the construction of a demonstration vehicle. Attention is presently given to the air-breathing propulsion system, and to flight-weight structural systems under consideration for both external heating and internal cryogenic tankage requirements. O.C.

A88-41288* National Aeronautics and Space Administration, Washington, D.C.
NATIONAL AERO-SPACE PLANE
WILLIAM M. PILAND (NASA, Arlington, VA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 219-222.
(AAS PAPER 87-127)

An account is given of the technology development management objectives thus far planned for the DOD/NASA National Aero-Space Plane (NASP). The technology required by NASP will first be developed in ground-based facilities and then integrated during the design and construction of the X-30 experimental aircraft. Five airframe and three powerplant manufacturers are currently engaged in an 18-month effort encompassing design studies and tradeoff analyses. The first flight of the X-30 is scheduled for early 1993. O.C.

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A88-37429#
KRYPTONITE THEY ARE NOT
BRUCE FRISCH Aerospace America (ISSN 0740-722X), vol. 26, May 1988, p. 16-18, 20, 26.

The thin but increasingly complex coatings that are needed to protect superalloys from hot combustion gases in modern jet engines are discussed. The historical development of these coatings is reviewed, and the methods of depositing the coatings are described, emphasizing the electron beam method. Cost aspects are considered, and the role of automation in the application of the coatings is addressed. C.D.

A88-37430#
GAS TURBINES CHALLENGE CERAMIC TECHNOLOGY
DAVE CARRUTHERS and JIM WIMMER (Allied-Signal Aerospace Co., Arlington, VA) Aerospace America (ISSN 0740-722X), vol. 26, May 1988, p. 22-24, 26.

The design of practical ceramics for gas turbine engines is discussed. The ceramic design process in this application is described, indicating the tasks necessary to achieve conceptualization, optimization, experimentation, and validation. The development of this design approach to more complex gas turbine engine systems over time is reviewed. Future developments in this area of ceramics science are briefly considered. C.D.

A88-38315
CORROSION-RESISTANT THERMAL BARRIER COATINGS
WING-FONG CHU and F. J. ROHR (Brown Boveri et Cie. AG, Heidelberg, Federal Republic of Germany) Advanced Ceramic Materials (ISSN 0883-5551), vol. 3, May 1988, p. 222-224. BMFT-supported research. refs

Results of an experimental study of the corrosion resistance of zirconia-based thermal barrier coatings to combustion products, such as vanadates and sulfates generated in fuel-fired gas turbines, are reported. With reference to results obtained for the system ZrO_2-Y_2O_3-SiO_2-Al_2O_3, it is shown that it is possible to enhance the corrosion resistance of ZrO_2-based thermal barrier coatings by the addition of Al_2O_3 and SiO_2. The addition of these oxides leads to the enveloping of $ZrO_2(Y_2O_3)$ crystallites by zirconium and aluminum silicates, which are formed during sintering and precipitate preferentially on the $ZrO_2(Y_2O_3)$ grain boundaries. V.L.

A88-38316
IMPROVING THE RELIABILITY OF SILICON NITRIDE - A CASE STUDY
JEFFREY T. NEIL, ARVID E. PASTO, and LESLIE J. BOWEN (GTE Laboratories, Inc., Waltham, MA) Advanced Ceramic Materials (ISSN 0883-5551), vol. 3, May 1988, p. 225-230. refs

Recent AGT engine test data indicate that, in prototype quantities, structural ceramics can be made capable of meeting the stringent mechanical constraints imposed by the turbine environment. Questions remain to be answered about the long-term capabilities of structural ceramics and their reliability in production quantities. The reliability of structural ceramics can be enhanced in three ways: by careful processing, improving fracture toughness using composites, and by appropriate NDE/proof-testing. Data generated by research in all three areas suggest that none of these alone is a panacea for the reliability problem. However, taken in combination, these data suggest that the necessary levels of reliability can be attained even in production ceramic turbine rotors. Research results on GTE AY6 sintered Si_3N_4 are presented to support this viewpoint. Author

A88-38490
DEVELOPMENT OF A VARIATIONAL METHOD FOR CHEMICAL KINETIC SENSITIVITY ANALYSIS
D. GROUSET, P. PILON, E. ZNATY (Societe Bertin et Cie., Tarnos, France), and S. GALANT (Societe Bertin et Cie., Les Milles, France) IN: Symposium (International) on Combustion, 21st, Munich, Federal Republic of Germany, Aug. 3-8, 1986, Proceedings. Pittsburgh, PA, Combustion Institute, 1988, p. 795-806; Discussion, p. 806, 807. DRET-supported research. refs

A novel method of variational sensitivity analysis is applied to the kinetics of aircraft engine combustors and validated by comparisons with the 'brute force' method for hydrogen-oxygen combustion in a stirred reactor assembly. The variational method is shown to require far less computational time; the method is also applied to complete kinetic schemes for methanol/oxygen and ethane/air combustion in a reactor assembly. The results obtained with reduced schemes for methanol, involving 11 reactions among the 88 original ones, appear satisfactory. O.C.

A88-39417#
MODERN SURFACE PROTECTIONS FOR AIRCRAFT
REINHOLD HOLBEIN Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 34-36.

The 20-year service life typical of aircraft generates demanding surface protection criteria against corrosion and such other possible forms of environmentally induced damage as erosion, temperature variations, and tribological action. Attention is presently given to the battery of fundamental properties, laboratory media, open-air weathering, and combined-load component tests, as well as flight tests, that must be conducted. The Dacromet 500 metalorganic coating is found to yield a good profile of results, even after 16 months of exposure to a marine atmosphere. O.C.

A88-40174
EFFECT OF LOAD DURATION ON THE FATIGUE BEHAVIOUR OF GRAPHITE/EPOXY LAMINATES CONTAINING DELAMINATIONS
D. S. SAUNDERS and T. J. VAN BLARICUM (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Composites (ISSN 0010-4361), vol. 19, May 1988, p. 217-228. refs

At high sustained loads it is known that creep-rupture can occur in short periods of time or contribute damage to carbon fiber composite components. This paper investigates the effect of load holds on the fatigue performance of impact damaged carbon fiber composite coupons by using two modified versions of a loading spectrum, static failure tests and application of sustained static loading, and examines damage growth together with coupon stiffness during fatigue testing. Stiffness degradation, shown to be associated with delamination growth, could be used to predict coupon failure. Author

A88-40486
ELEVATED-TEMPERATURE AL ALLOYS FOR AIRCRAFT STRUCTURE
RICHARD A. RAINEN and JOHN C. EKVALL (Lockheed Aeronautical Systems Co., Sunland, CA) Journal of Metals (ISSN 0148-6608), vol. 40, May 1988, p. 16-18. refs

Elevated-temperature powder metallurgy (P/M) aluminum alloys are being developed to replace titanium aircraft structure materials for operation in the 300-600 F temperature range. Typical mechanical properties of P/M Al-Fe-Ce and Al-Fe-V-Si alloys are superior to those of conventional materials, and cost savings of 50 to 70 percent have been projected for these alloys which can be fabricated and processed using methods similar to those used in the production of conventional aluminum. Author

N88-22092# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A STUDY OF DAMAGE TOLERANCE IN CURVED COMPOSITE PANELS M.S. Thesis
BRENDAN L. WILDER Mar. 1988 152 p
(AD-A190617; AFIT/GA/AA/88M-3) Avail: NTIS HC A08/MF A01 CSCL 11D

As more and more composite materials are used in modern aircraft construction, the understanding of the damage tolerance of this relatively stiff, brittle, anisotropic material becomes important to designers. The behavior of a cylindrical composite panel made of AS4/3501-6 graphite/epoxy with ply orientations is investigated. Abrasion and burn surface damage was physically modeled in the panels. The panels were then tested by compressively loading them and a comparison was made to buckling predictions obtained. These tests indicated that panels which have suffered minor surface damage do not deviate significantly from buckling predictions. Composite laminates subjected to a low speed impact, such as a dropped tool or a manufacturing load, often develop an internal delamination. Since curved panels are 3-dimensional, and buckling is a non-linear phenomenon, the compressive load which will cause curved panels to become unstable is extremely hard to predict analytically. A technique whereby the local buckling loads at the delamination may be predicted using a 2-D model with a plane strain correction is presented. GRA

N88-22115# Stanford Univ., Calif. High Temperature Gasdynamics Lab.
TURBULENT REACTING FLOWS AND SUPERSONIC COMBUSTION Annual Report, 15 Sep. 1986 - 30 Sep. 1987
C. T. BOWMAN, R. K. HANSON, M. G. MUNGAL, and W. C. REYNOLDS 30 Sep. 1987 28 p Original contains color illustrations
(Contract F49620-86-K-0022)
(AD-A189690; AFOSR-87-1899TR) Avail: NTIS HC A03/MF A01 CSCL 21B

An experimental and computational investigation of supersonic combustion flows is in progress. The principal objective of the research is to gain a more fundamental understanding of mixing and chemical reaction in supersonic flows. The research effort comprises three inter-related elements: (1) an experimental study of mixing and combustion in a supersonic plane mixing layer; (2) development of laser-induced fluorescence techniques for time-resolved two-dimensional imaging of species concentration, temperature, velocity and pressure; and, (3) numerical simulations of compressible reacting flows. The design of the supersonic plane mixing layer was completed and the high-pressure gas storage system was installed. The pulsed lasers and camera systems, to be used for two-dimensional flow field imaging, were installed and initial performance evaluations are in progress. This work has focussed on development of appropriate numerical methods for performing full-turbulence simulations of high-speed compressible flows and on the application of these methods to temporally and spatially developing compressible mixing layers. The effort to date has identified several promising numerical methods for compressible flow problems. In addition, a code was developed for compressible mixing layers, and initial simulation using this code shows interesting features, such as imbedded shock waves, in high-speed mixing layers. GRA

N88-22121# California Inst. of Tech., Pasadena.
INVESTIGATION OF COMBUSTION IN LARGE VORTICES Annual Technical Report, Sep. 1986 - Sep. 1987
FRANK E. MARBLE 12 Oct. 1987 22 p
(Contract AF AFOSR-0286-84)
(AD-A190406) Avail: NTIS HC A03/MF A01 CSCL 21B

The investigations of non-steady and unstable combustion in a dump combustor have been completed. The large amplitude driving mechanism centers on the periodic formation and combustion of a large vortex, the phase of heat release being governed by both gas dynamic and chemical delay times. This mechanism is now very well understood, both in principle and in quantitative detail. These results make it a prime candidate for investigations into active control of unstable combustion. The unsteady combustion facility is now being modified to study the details of combustion processes in large vortices utilizing a CID image intensified camera and an LDV for velocity measurements in the hot gas. This study constitutes an essential element in a larger study of shock enhancement for combustion of hydrogen in supersonic burners. GRA

N88-22405*# Sverdrup Technology, Inc., Cleveland, Ohio.
STRUCTURAL ANALYSES OF ENGINE WALL COOLING CONCEPTS AND MATERIALS
ALBERT KAUFMAN *In* NASA. Lewis Research Center, Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 265-280 May 1988
Avail: NTIS HC A14/MF A01 CSCL 11D

The severe thermal environments under which hypersonic aircraft such as the National Aerospace Plane (NASP) will operate require cooling of the engine walls, especially in the combustor. A preliminary assessment is made of some candidate materials based on structural analyses for a number of convective cooling configurations. Three materials were studied: graphite/copper and tungsten/copper composite alloys with 50 percent fiber volume fractions and a wrought cobalt-base superalloy, Haynes 188. Anisotropic mechanical and thermal properties for the composites were obtained from a computer code, ICAN, which determines the composite material properties from the individual properties of the fiber and matrix materials. The structural analyses were performed by using the MARC nonlinear finite element code. Heat transfer analyses were conducted to calculate the metal temperature distributions. Author

N88-22427*# Pratt and Whitney Aircraft, East Hartford, Conn.
FATIGUE DAMAGE MODELING FOR COATED SINGLE CRYSTAL SUPERALLOYS
DAVID M. NISSLEY *In* NASA. Lewis Research Center, Lewis Structures Technology, 1988. Volume 3: Structural Integrity Fatigue and Fracture Wind Turbines HOST p 259-270 May 1988
(Contract NAS3-23939)
Avail: NTIS HC A16/MF A01 CSCL 11F

A high temperature, low-cycle fatigue life prediction method for coated single crystal nickel-base superalloys is being developed. The method is being developed for use in predicting crack initiation life of coated single crystal turbine airfoils. Although the models are being developed using coated single crystal PWA 1480, they should be readily adaptable to other coated nickel-base single crystal materials. The coatings choosen for this effort were of two generic types: a low pressure plasma sprayed NiCoCrAlY overlay, designated PWA 286, and an aluminide diffusion, designated PWA 273. In order to predict the useful crack initiation life of airfoils, the constitutive and failure behavior of the coating/substrate combination must be taken into account. Coatings alter the airfoil surface microstructure and are a primary source from which cracks originate. The adopted life prediction approach addresses this complexity by separating the coating and single crystal crack initiation regimes. This provides a flexible means for using different life model formulations for the coating and single crystal materials. At the completion of this program, all constitutive and life model formulations will be available in equation form and as software. The software will use the MARC general purpose finite element code to drive the constitutive models and calculate life parameters. Author

N88-22940# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A STUDY OF FAILURE CHARACTERISTICS IN THERMOPLASTIC COMPOSITE MATERIAL M.S. Thesis
ROBERT J. MARTIN Mar. 1988 236 p
(AD-A190613; AFIT/GA/AA/88M-2) Avail: NTIS HC A11/MF A01 CSCL 11D

The recently introduced thermoplastic composite material, graphite polyetherether-ketone (Gr/PEEK) APC-2, promises lower costs, lower part weight, and higher operating temperatures. This new class of organic material has fracture toughness properties superior to those of graphite epoxy. This thesis examines the failure characteristics of Gr/PEEK through an experimental investigation and through the application of a fully nonlinear ply-by-ply finite element technique. The experimental investigation of Gr/PEEK APC-2 involved the testing of 34 tension and compression coupons to derive basic material properties for use with the finite element program. This investigation provided further data on the application of tensile loads to Gr/PEEK containing circular discontinuities. This study also proved that a nonlinear finite element program can closely approximate progressive ply failure in a Gr/PEEK laminate. This research reinforced the proposition that the thermoplastic matrix does produce a reliable composite that should be considered for use on aircraft, spacecraft, and space facilities. GRA

N88-22949*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TOWARDS A DAMAGE TOLERANCE PHILOSOPHY FOR COMPOSITE MATERIALS AND STRUCTURES
T. KEVIN OBRIEN (Army Aerostructures Directorate, Hampton, Va.) Mar. 1988 63 p
(Contract DA PROJ. 1L1-61102-AH-45-C)
(NASA-TM-100548; USAAVSCOM-TM-88-B-009; NAS 1.15:100548) Avail: NTIS HC A04/MF A01 CSCL 11D

A damage-threshold/fail-safe approach is proposed to ensure that composite structures are both sufficiently durable for economy of operation, as well as adequately fail-safe or damage tolerant for flight safety. Matrix cracks are assumed to exist throughout the off-axis plies. Delamination onset is predicted using a strain energy release rate characterization. Delamination growth is accounted for in one of three ways: either analytically, using delamination growth laws in conjunction with strain energy release rate analyses incorporating delamination resistance curves; experimentally, using measured stiffness loss; or conservatively, assuming delamination onset corresponds to catastrophic delamination growth. Fail-safety is assessed by accounting for the accumulation of delaminations through the thickness. A tension fatigue life prediction for composite laminates is presented as a case study to illustrate how this approach may be implemented. Suggestions are made for applying the damage-threshold/fail-safe approach to compression fatigue, tension/compression fatigue, and compression strength following low velocity impact. Author

N88-22954# McDonnell Aircraft Co., St. Louis, Mo.
NONDESTRUCTIVE EVALUATION OF LARGE SCALE COMPOSITE COMPONENTS Final Report, 25 Sep. 1984 - 31 Mar. 1987
DANIEL C. KING, R. D. LAWSON, and B. J. ROMINE Jan. 1988 63 p
(Contract F33615-84-C-5017)
(AD-A190998; AFWAL-TR-87-4116) Avail: NTIS HC A04/MF A01 CSCL 11D

This report covers the development of a reciprocating time-of-flight ultrasonic inspection system capable of rapid scanning of large area composite structures. Representative aircraft composite structures with flaw inclusions were fabricated to evaluate the effects of scanner design, coupling characteristics, part curvature, near and far surface defect detection, imaging, and data acquisition and storage capabilities. The results were used to combine a mechanical scanner, software, and electronics equipment into a working breadboard system. Breadboard evaluation results indicate that a downsized portable system is a viable inspection tool, and produces production quality ultrasonic C-scan images at comparable production scanning rates. GRA

N88-22989 Joint Publications Research Service, Arlington, Va.
MODEL STUDY OF THERMAL STRESSES IN GAS-TURBINE BLADES WITH PROTECTIVE COATING Abstract Only
G. N. TRETYACHENKO, K. P. BUYSKIKH, L. V. KRAVCHUK, and G. R. SEMENOV *In its* JPRS Report: Science and Technology. USSR: Materials Science p 4 17 Mar. 1988 Transl. into ENGLISH from Problemy Prochnosti (Kiev, USSR), no. 5, May 1987 p 67-70
Avail: Issuing Activity

A model study of thermal stresses in gas turbine blades with protective coating was made, such blades being simulated by nine different wedges of the ZhS6U heat resistant alloy. Wedges of different sizes and chords were coated by electron beam method with Ni-Co-Cr-Al-Y, Ni-Cr-Al-Y, and Co-Cr-Al-Y alloys. For comparison, one wedge of each size was not coated. These wedges were tested under a heat load simulation. The test results based on measurement of surface temperature indicate that a proper coating can increase the asymmetry of the thermal load cycle with a shift of stresses more into the compressive range while lowering their amplitude so that such a coating will not only protect blades against corrosion and erosion but also raise their mechanical load capacity. Author

N88-22990 Joint Publications Research Service, Arlington, Va.
DEPENDENCE OF STRUCTURE OF STABILIZED ZRO2 COATINGS ON CONDENSATION RATE Abstract Only
A. M. MARTIROSYAN, V. V. GRABIN, N. I. GRECHANYUK, I. YA. DZYKOVICH, A. A. TROFIMENKO, and A. L. SAMSONOV *In its* JPRS Report: Science and Technology. USSR: Materials Science p 4-5 17 Mar. 1988 Transl. into ENGLISH from Problemy Spetsialnoy Elektrometallurgii (Kiev, USSR), no. 2, Apr. - Jun. 1987 p 47-51
Avail: Issuing Activity

An experimental study of ZrO2 coatings stabilized with Y2O3 for gas turbine blades was made, its purpose being to find the causes for their high thermal shielding capability as well as their proneness to peeling off the heat resistant steel. The coating material was produced by mixing powders of pure ZrO2 and high purity Y2O3 in a 23:2 ratio and then pressing the mixture. These rods were coated by means of electron beam under a vacuum with an 8 percent Y2O3 stabilizer. These specimens were then heat treated. The bond strength was measured by counting the number of thermal cycles withstood. Microstructural exams with quantitative x-radiographic analyses and microhardness measurements revealed formation of two layers. Coatings produced by condensation at a rate of 0.56 micron/min withstood more than 20 thermal cycles, those produced by condensation at a rate of 1.52 micron/min broke down after one or two cycles. Author

N88-22998# Brown, Boveri und Cie, A.G., Mannheim (West Germany). Zentrales Labor fuer Werkstofftechnik.
EVALUATION OF CERAMIC THERMAL BARRIER COATINGS FOR GAS TURBINE ENGINE COMPONENTS European Concerted Action.COST 501-D28Final Report, Jan. 1983 - Dec. 1985
RALF BUERGEL, KLAYS SCHNEIDER, and BEATE TRUECK Aug. 1986 53 p
(ETN-88-91947) Avail: NTIS HC A04/MF A01

Duplex thermal barrier systems were assessed under test conditions relevant for stationary gas turbines including thermal cycling, cyclic oxidation, and hot corrosion. Attention is focused on ZrO2 -7/8 wt percent Y2O3 ceramic systems that prove to be most durable for turbine applications. The test results reveal that thermal barrier systems are available which are sufficiently thermal cyclic resistant. Oxidation of the metallic bond coat is identified as the life-limiting process while hot corrosion is less of a problem at high temperatures (950 C or above). An approach to overcome early degradation of the bond coat is to apply layers with few processing defects, i.e., to replace air plasma spraying of metallic coats by vacuum chamber spraying or inert gas shroud spraying wherever it is technically feasible. ESA

N88-23009# Naval Air Development Center, Warminster, Pa. Air Vehicle and Crew Systems Technology Directorate.
DEVELOPMENT OF A HIGH-TEMPERATURE RESISTANT (700 F), CORROSION-PREVENTIVE ORGANIC COATING Final Report, Oct. 1984 - Sep. 1986
STEPHEN J. SPADAFORA 11 Jul. 1987 41 p Original contains color illustrations
(AD-A191407; NADC-87171-60) Avail: NTIS HC A03/MF A01 CSCL 11C

Current materials used in this temperature range (700 F) have significant deficiencies. Ceramic coatings provide good protection, but are difficult to apply and require a high-temperature cure. Standard paints can be easily applied and air dry, but they provide poor protection against corrosion. While materials requiring high-temperature cure and special application equipment can be used in manufacturing processes, they are not practical for most aircraft repair and touchup applications. Therefore, for these applications, the air-dry systems are primarily used. These systems provide barrier protection against the environment. GRA

N88-23011# Sun Refining and Marketing Co., Marcus Hooks, Pa. Applied Research and Development Dept.
TURBINE FUELS FROM TAR SANDS BITUMEN AND HEAVY OIL. VOLUME 2, PHASE 3: PROCESS DESIGN SPECIFICATIONS FOR A TURBINE FUEL REFINERY CHARGING SAN ARDO HEAVY CRUDE OIL Final Report, 1 Jun. 1985 - 31 Mar. 1987
A. F. TALBOT, J. R. SWESEY, and L. G. MAGILL Sep. 1987 247 p
(Contract F33615-83-C-2352)
(AD-A190120; AFWAL-TR-87-2043-VOL-2) Avail: NTIS HC A11/MF A01 CSCL 21D

An engineering design was developed for a 50,000 BPSD grass-roots refinery to produce aviation turbine fuel grades JP-4 and JP-8 from San Ardo heavy crude oil. The design was based on the pilot plant studies described in Phase 3 - Volume 1 of this report. The detailed plant design described in this report was used to determine estimated production costs. GRA

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A88-37108* California Inst. of Tech., Pasadena.
ROTORDYNAMIC FORCES ON CENTRIFUGAL PUMP IMPELLERS
R. FRANZ, N. ARNDT, T. K. CAUGHEY, C. E. BRENNEN, and A. J. ACOSTA (California Institute of Technology, Pasadena) IN: Conference on Fluid Machinery, 8th, Budapest, Hungary, Sept. 1987, Proceedings. Volume 1. Budapest, Akademiai Kiado, 1987, p. 252-258. refs
(Contract NAS8-33108)

The asymmetric flow around an impeller in a volute exerts a force upon the impeller. To study the rotordynamic force on an impeller which is vibrating around its machine axis of rotation, the impeller, mounted on a dynamometer, is made to whirl in a circular orbit within the volute. The measured force is expressed as the sum of a steady radial force and an unsteady force due to the eccentric motion of the impeller. These forces were measured in separate tests on a centrifugal pump with radically increased shroud clearance, a two-dimensional impeller, and an impeller with an inducer, the impeller of the HPOTP (High Pressure Oxygen Turbopump) of the SSME (Space Shuttle Main Engine). In each case, a destabilizing force was observed over a region of positive whirl. Author

A88-37110
CASCADE LIFT RATIOS FOR RADIAL AND SEMIAXIAL ROTATING CASCADES
P. HERGT (Klein, Schanzlin, und Becker AG, Frankenthal, Federal Republic of Germany) IN: Conference on Fluid Machinery, 8th, Budapest, Hungary, Sept. 1987, Proceedings. Volume 1. Budapest, Akademiai Kiado, 1987, p. 324-331. refs

Hergt's (1983) method for the calculation of the lift and drag coefficients of rotating radial and semiaxial cascades is presently used to deduce the lift coefficient for a single vane in flows that are inclined to the axis of rotation. It is shown that the cascade lifting ratios of rotating radial cascades are similar to the Weinig (1925) curves. Deductive results are obtained which support the possibility of judging a wide variety of turbomachines from a single, general viewpoint. O.C.

A88-37351

WORLD CONGRESS ON COMPUTATIONAL MECHANICS, 1ST, AUSTIN, TX, SEPT. 22-26, 1986, PROCEEDINGS

J. TINSLEY ODEN, ED. (Texas, University, Austin) Congress sponsored by the University of Texas, NSF, U.S. Navy, et al. Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 64, Oct. 1987, 585 p. For individual items see A88-37352 to A88-37368.

Recent advances in computational mechanics are examined in reviews and reports. Topics addressed include CFM, mesh generation and rezoning, solid mechanics, and numerical methods and supercomputing. Particular attention is given to a deterministic view of shear turbulence; a numerical model for supersonic reacting mixing layers; simulation of transonic flow in radial compressors; engineering applications of the vortex cloud method; composite grid schemes for computational aerodynamics; nonlinear analysis of isotropic, orthotropic, and laminated plates and shells; and mixed and penalty formulations for FEM analysis of an eigenvalue probem in electromagnetism. T.K.

A88-37549

LIFE OF GAS TURBINE ENGINE DISKS WITH CRACKS [ZHIVUCHEST' DISKOV GTD S TRESHCHINAMI]

N. V. STEPANOV, V. N. SHLIANNIKOV, V. V. OMEL'CHENKO, and I. N. SHKANOV Problemy Prochnosti (ISSN 0556-171X), April 1988, p. 108-111. In Russian. refs

Results of a study of the deceleration of critical cracks in gas turbine disks of VT3-1 titanium alloy under conditions of low-cycle fatigue are reported. In the experiments, cracks were arrested by holes located in areas that were less stressed than the areas where the initial cracks grew from the disk grooves. It is shown that the method of crack arrest described here makes it possible to extend the life of disks by 36-60 percent. V.L.

A88-37661

COMPUTER SIMULATION OF TURBULENT JETS AND WAKES [MODELIROVANIE NA EVM TURBULENTNYKH STRUI I SLEDOV]

S. M. BELOTSERKOVSKII, A. V. DVORAK, A. I. ZHELANNIKOV, and V. N. KOTOVSKII IN: Problems of turbulent flows. Moscow, Izdatel'stvo Nauka, 1987, p. 129-134. In Russian. refs

The large-scale turbulence of plane jets and wakes is investigated using an ideal medium scheme. A class of problems is considered without any additional hypotheses being used. The present study is a further development of the general concept of modeling the principal features and microeffects of flow past bodies at high Reynolds numbers on the basis of nonstationary equations of an ideal medium. For smooth bodies, where separation sites are not fixed, the ideal medium model has to be supplemented by a boundary layer scheme. V.L.

A88-37929*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MEASUREMENT OF LEADING EDGE VORTICES FROM A DELTA WING USING A THREE COMPONENT LASER VELOCIMETER

JAMES F. MEYERS (NASA, Langley Research Center, Hampton, VA) and TIMOTHY E. HEPNER (U.S. Army, Aviation Research and Development Command, Hampton, VA) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 223-233. refs

(AIAA PAPER 88-2024)

A demonstration of the capabilities of a three-component laser velocimeter to provide a detailed experimental database of a complex flow field is presented. The orthogonal three-component laser velocimeter was used to measure the leading edge vortex flow field above a 75 deg delta wing at angles-of-attack of 20.5 deg and 40.0 deg. The resulting mean velocity and turbulence intensity measurements are presented. The laser velocimeter is described in detail including a description of the data processing algorithm. A full-error analysis was conducted and the results presented. Author

A88-37930*# Notre Dame Univ., Ind.

VISUALIZATION TECHNIQUES FOR STUDYING HIGH ANGLE OF ATTACK SEPARATED VORTICAL FLOWS

ROBERT C. NELSON (Notre Dame, University, IN) IN: Aerodynamic Testing Conference, 15th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 234-241. Research sponsored by the University of Notre Dame and NASA. refs

(AIAA PAPER 88-2025)

Flow visualization techniques can provide information on high angle of attack separated flows around slender aircraft configurations that may be unobtainable otherwise. At large angles of attack the flow field is dominated by vortical structures originating on the forebody wing extension, wing and forward control surfaces. Several techniques that are suitable for tracking vortices in subsonic wind tunnels are introduced. A discussion of visualization photographs and quantitative data obtained from visualization studies on vortex trajectory and breakdown position on both static and dynamic wind tunnel models is presented. Author

A88-38116

A ROLE FOR FIBRE OPTICS IN ANTENNA MEASUREMENTS

W. M. KEMP and A. T. TICKNER (Department of Defence, Electronics Research Laboratory, Adelaide, Australia) Journal of Electrical and Electronics Engineering, Australia (ISSN 0725-2986), vol. 7, Dec. 1987, p. 278-281.

This paper describes two instrumentation systems which utilize fiber optics to improve the quality of antenna measurements. Firstly, the problems encountered in determining the free space patterns of antennas fitted to aircraft are discussed and a solution using fiber optics is given. Secondly, the problems associated with the measurement of capacitance of electrically short antennas (or open-bodied structures) is discussed and an instrument is described which can make these measurements with greatly improved accuracy. Author

A88-38181#

SOME ASPECTS OF THE RELIABILITY ANALYSIS OF AIRCRAFT STRUCTURES

DEPEI ZHU and FUJIA LIN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A41-A49. In Chinese, with abstract in English. refs

This paper briefly introduces some research concerning the reliability analysis of aircraft structures. A set of fundamental equations with some numerical examples for computing the failure rate of aircraft structures in service is presented. The numerical results are used to estimate the influence of various factors on the reliability of aircraft structures and to evaluate the current criteria of aircraft fatigue probability. Some new methods are presented and some new results are obtained with regard to the probability of detection, the distribution of initial flaw length, and the distribution of k1c. C.D.

A88-38187#

BEHAVIOUR OF DAMAGE TOLERANCE OF COMPOSITE AIRCRAFT STRUCTURES

ZHEN SHEN (Aircraft Structural Strength Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Feb. 1988, p. B1-B10. In Chinese, with abstract in English. refs

An account is given of the features and performance of a manual landing flare and touchdown system capable of great precision, as demonstrated by its installation in the NASA Quiet Short-haul Research Aircraft (QSRA). The integrated cockpit display and closed-loop control employed constitutes a trajectory-augmentation system that extends QSRA flight control from augmentation of altitude, flight path angle, and airspeed, to the augmentation of the trajectory itself. The + or - 18 ft touchdown dispersion achieved is approximately equal to that obtained during aircraft carrier trials of the same aircraft. O.C.

A88-38448
INFORMATION PROPERTIES OF COMPLEX RADAR ANGULAR-COORDINATE ESTIMATES [INFORMATIVNYE SVOISTVA KOMPLEKSNYKH RADIOLOKATSIONNYKH OTSENOK UGLOVOI KOORDINATY]
G. G. DZHAVADOV Radioelektronika (ISSN 0021-3470), vol. 31, April 1988, p. 95, 96. In Russian.

An approach to evaluating the information properties of complex radar angular-coordinate estimates is developed. The results are pertinent to the meteorological-radar observation of thunderstorm activity in connection with the assurance of flight safety. B.J.

A88-39012#
THE TURBULENCE CHARACTERISTICS OF A SINGLE IMPINGING JET THROUGH A CROSSFLOW
J. M. M. BARATA, D. F. G. DURAO, M. V. HEITOR (Instituto Superior Tecnico, Lisbon, Portugal), and J. J. MCGURIK (Imperial College of Science and Technology, London, England) IN: Symposium on Turbulent Shear Flows, 6th, Toulouse, France, Sept. 7-9, 1987, Proceedings. University Park, PA, Pennsylvania State University, 1987, p. 13-5-1 to 13-5-11. Research supported by the Royal Aircraft Establishment. refs

The mean and turbulent velocity characteristics of a single round jet impinging on a ground plate after penetrating a confined cross-flowing stream were measured using laser Doppler anemometry. Special attention was given to the effect of the velocity ratio between the jet and the cross flow for a single impingement height, examining the jet-to-cross flow velocity ratios in the range 30-73. The experimental results (relevant to the problem of estimating the flow field beneath a STOVL aircraft close to the ground) were compared with predictions of the flow field with the k-epsilon model of turbulence. I.S.

A88-40117* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
DEVELOPMENT OF A BLOCK LANCZOS ALGORITHM FOR FREE VIBRATION ANALYSIS OF SPINNING STRUCTURES
K. K. GUPTA (NASA, Flight Research Center, Edwards, CA) and C. L. LAWSON (Harvey Mudd College, Claremont, CA) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 26, May 1988, p. 1029-1037. refs

This paper is concerned with the development of an efficient eigenproblem solution algorithm and an associated computer program for the economical solution of the free vibration problem of complex practical spinning structural systems. Thus, a detailed description of a newly developed block Lanczos procedure is presented in this paper that employs only real numbers in all relevant computations and also fully exploits sparsity of associated matrices. The procedure is capable of computing multiple roots and proves to be most efficient compared to other existing similar techniques. Author

A88-40175
THE ROLE OF NON-DESTRUCTIVE TESTING IN THE AIRWORTHINESS CERTIFICATION OF CIVIL AIRCRAFT COMPOSITE STRUCTURES
A. MAHOON (British Aerospace, PLC, Kingston-upon-Thames, England) Composites (ISSN 0010-4361), vol. 19, May 1988, p. 229-235. refs

Airworthiness requirements for civil aircraft structures, particularly those fabricated from carbon fiber-reinforced resins, are discussed and the use of non-destructive testing to monitor the quality of these structures at each stage of development is reviewed. Non-destructive testing techniques for series-production items are described with information on the type of defects detected by the various techniques. Non-destructive testing techniques under development and future trends in the use of the proposed testing techniques are also included. Author

A88-40280
ADDENDUM-DEDENDUM TYPE CIRCULAR-ARC GEARS FOR AERO-ENGINE ACCESSORY DRIVE GEARBOX - A CRITICAL ANALYSIS OF STRENGTH-TO-WEIGHT RATIO
K. LINGAIAN (Bangalore, University, India) and K. RAMACHANDRA (Gas Turbine Research Establishment, Bangalore, India) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 424-428.

Addendum-dedendum type of Wildhaber-Novikov gears have two contact points in an axial pitch of the gear wheel. The advantage of this profile vis-a-vis all-addendum type is discussed and the bending stress induced in these profiles is studied for various profile radii by photoelastic technique. A factor of two was estimated as the bending-strength advantage for these profiles as compared to all-addendum type of gears. Author

A88-40317
THERMAL STATE OF A TURBOFAN ROTOR [TEPLOVOE SOSTOIANIE KOLESA TURBOVENTILIATORA]
B. D. BILEKA, A. M. DIACHENKO, and I. S. ORINICHEV (AN USSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR) Promyshlennaia Teplotekhnika (ISSN 0204-3602), vol. 10, no. 2, 1988, p. 49-55. In Russian.

Results of an experimental study of the thermal state of a combined turbofan rotor consisting of a peripheral turbine stage and a central fan stage are reported. In particular, attention is given to the effect of gas temperature, air flow rate, and rotation speed on temperature distributions at characteristic points of the rotor. The relative dimensionless temperatures of the turbofan rotor are shown to be constant under all the regimes investigated. An approximate method is proposed for calculating the temperature of the rotor elements, and the results of calculations are compared with experimental data. V.L.

A88-40327
THE ROLE OF ELECTRON MICROSCOPY IN GAS TURBINE MATERIALS DEVELOPMENT
R. A. SPRAGUE (GE Engineering Materials and Technology Laboratories, Lynn, MA) and R. W. SMASHEY (GE Laboratory Service Technology, Cincinnati, OH) IN: MiCon 86: Optimization of processing, properties, and service performance through microstructural control; Proceedings of the Symposium, Philadelphia, PA, May 15, 16, 1986. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 165-182. refs

The application of electron microscopy techniques to gas turbine materials development and its practical benefit to aircraft engine materials and process development are addressed. Scanning electron microscopy, image analysis, electron microprobe analysis, and analytical electron microscopy are considered, giving application examples. Future analytical development needs are briefly discussed. C.D.

A88-40535#
FLAT PANEL DISPLAY TRENDS
TAKEAKI SHIGETO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 408, 1988, p. 35-39. In Japanese.

A88-40713*# Old Dominion Univ., Norfolk, Va.
AERODYNAMIC INVESTIGATION BY INFRARED IMAGING
A. SIDNEY ROBERTS, JR., GRIFFITH J. MCREE (Old Dominion University, Norfolk, VA), and EHUD GARTENBERG IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 121-128.
(Contract NAG1-735)
(AIAA PAPER 88-2523)

Infrared imaging systems can be used to measure temperatures of actively heated bodies immersed in an airstream. This monitoring

of the convective heat transfer process, provides also information about the interaction between the body and the flow. The concept appeals to Nusselt/Reynolds numbers relations in order to produce data of interest from surface temperatures. Two test cases are presented and reference is made to analytical results: the mapping of a laminar jet and the temperature distribution along a constant power heated flat plate in laminar boundary layer regime. Although this research is currently focused on low speed aerodynamics, the extension to high speed aerodynamics, where the body undergoes frictional heating is of interest in this context, too.
Author

A88-40759#
MODELLING THE INFLUENCE OF SMALL SURFACE DISCONTINUITIES IN TURBULENT BOUNDARY LAYERS
H. H. NIGIM (Birzeit University, Jordan) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 561-567. refs
(AIAA PAPER 88-2594)
The paper is concerned with flow modeling in the presence of small isolated surface discontinuities, such as those formed on aircraft wings around auxiliary lifting and control surfaces. Methods of determining step changes in the boundary layer integral parameters are developed and techniques for modeling the consequent reattaching sub-boundary layer are discussed. Examples of flow prediction results are given which compare favorably with experimental data. This modeling could easily be adapted to become an adjunct to any integral boundary layer prediction technique.
Author

A88-40871#
ASSESSMENT OF TRANSIENT TESTING TECHNIQUES FOR ROTOR STABILITY TESTING
FREDERICK A. TASKER and INDERJIT CHOPRA (Maryland, University, College Park) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988. 13 p. refs
(Contract DAAG29-83-K-0002)
(AIAA PAPER 88-2401)
The task of estimating the damping of any mode for a helicopter rotor becomes complicated by the presence of undamped responses at the rotor harmonics, high measurement noise, the presence of close modes and the difficulty of exciting modes in the rotating environment. A systematic assessment of two transient data analysis techniques, the Moving-Block analysis method and the Sparse Time Domain technique for online estimation of damping is performed using a numerical simulation. Two refinements in Moving-Block analysis are introduced; recursive spectral analysis with improved frequency resolution, and a simple frequency domain interpretation for the Hanning window to reduce leakage from close modes. The recently developed Spare Time Domain technique is also applied to damping estimation from the numerically simulated transient response data. This technique reduces the time response into an eigenvalue problem of a sparse upper Hessenberg matrix. The effect of the Singular Value Decompositon solution technique on this method, is studied. The performance evaluation of both analysis techniques is made for noisy data, close damped and undamped modes, and for low and high damping levels. Moving-Block analysis is a simple technique and is quite effective in estimating the damping of a mode from noisy data, whereas the Sparse Time Domain is very effective in estimating the damping of close modes.
Author

A88-41219
ANALYSIS OF LIMIT CYCLE FLUTTER OF AN AIRFOIL IN INCOMPRESSIBLE FLOW
Z. C. YANG and L. C. ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Sound and Vibration (ISSN 0022-460X), vol. 123, May 22, 1988, p. 1-13. refs
Experimental and theoretical results are presented on several types of self-excited oscillations of a two-dimensional wing model with nonlinear pitching stiffness. A double limit cycle flutter is noted in low speed wind tunnel testing of a wing model with free play in pitch. Harmonic balance analyses confirm these sustained oscillations and reveal two other unstable limit cycles. Flutter analysis is performed using a digital simulation method. Good agreement is obtained between theoretical and experimental results.
R.R.

N88-22276# Hughes Aircraft Co., El Segundo, Calif.
ADVANCED CAPACITOR DEVELOPMENT Interim Report, Oct. 1984 - Apr. 1986
ROBERT S. BURITZ 1987 158 p
(Contract F33615-84-C-2424)
(AD-A189985; AFWAL-TR-86-2073) Avail: NTIS HC A08/MF A01 CSCL 09A
This document describes the technical approach taken by Hughes Aircraft Company for the development and testing of ac filter capacitors for airborne applications which will have a higher operating temperature than presently available. This program will result in improved lightweight, highly reliable filter capacitors operating at ambient temperatures exceeding 200 C, which will significantly advance the state of the art in capacitor technology. Two problems faced in achieving higher operating temperatures are the temperature limitation of the dielectric materials and thermal management of the heat generated. Failures are usually caused by the dissipation of relatively large amounts of power in a poorly cooled volume. These failures can take the form of thermal runaway, insulation failure because of very great local hot-spot temperatures, and excessive thermal expansion. Because the thermal properties of films available for capacitor use range from about 115 to more than 450 C, operating temperatures up to 300 to 400 C appear to be feasible. Since these numbers far exceed operating temperatures reported in the literature, the question arises as to the reason for the large difference. than 450 C, operating temperatures up to 300 to 400 C appear to be feasible. Since these numbers far exceed operating temperatures reported in the literature, the question arises as to the reason for the large difference.
GRA

N88-22290# Instituto Nacional de Tecnica Aeroespacial, Esteban Terradas, Torrejon de Ardoz (Spain). Dept. de Aerodinamica y Navegabilidad.
A PANEL METHOD BASED ON VELOCITY POTENTIAL TO COMPUTE HARMONICALLY OSCILLATING LIFT SURFACE SYSTEMS [METODO DE PANELES BASADO EN EL POTENCIAL DE VELOCIDADES PARA EL CALCULO DE SISTEMAS DE SUPERFICIES SUSTENTADORAS OSCILANTES ARMONICAMENTE]
LUIS P. RUIZCALAVERA 1987 13 p In SPANISH; ENGLISH summary Presented at the 5th International Congress on Numerical Methods in Laminar and Turbulent Flow, Montreal, Quebec, 6-10 Jul. 1987
(ETN-88-91886) Avail: NTIS HC A03/MF A01
A numerical method to calculate unsteady pressure distributions on systems of interferring lifting surfaces harmonically oscillating in incompressible flow was developed. Unlike the conventional approach to this kind of problem which use Prandtl's acceleration potential, this method is based on the velocity potential, whose simplicity allows to take into account thickness effects. Special attention is paid to the treatment of the wake influence, by far the most difficult problem in this type of method. The linearized version shows excellent agreement with techniques based on acceleration potential.
ESA

N88-22300# Technion - Israel Inst. of Tech., Haifa.
VISUALISATION OF THE FLOW AT THE TIP OF A HIGH SPEED AXIAL FLOW TURBINE ROTOR Final Report
J. BINDON, D. ALDER, and I. IANOVICI Nov. 1987 60 p
(Contract AF-AFOSR-0308-85)
(AD-A189928) Avail: NTIS HC A04/MF A01 CSCL 20D
The previous work having relevance to the flow in the region of an unshrouded turbine rotor blade tip was examined. It was found that, although extensive information is available on the effect of leakage flow on the loss mechanisms on the suction side of

the blade, an almost complete dearth of detailed information exists on the flow structure and mechanisms in the pressure side corner and tip gap regions which are considered important with respect to blade cooling. It would thus seem essential to lay a foundation of understanding from simple models and ending with the complex full speed situation. A logical qualitative prediction of the expected flows is presented. Apart from being complex with various zones of flow behaving almost independently from each other, the effect of upstream tangential unsymmetry (nozzle wakes) was shown to complicate the flow visualization technique and render the normal type of continuous tracer injection of no use. Thus either an experimental rig is required which has tangentially uniform flow upstream of the rotor or a new type of pulse trace technique is needed. It is suggested that both of these requirements be adopted. GRA

N88-22305# Grumman Aerospace Corp., Bethpage, N.Y. Corporate Research Center.
ON THE PREDICTION OF HIGHLY VORTICAL FLOWS USING AN EULER EQUATION MODEL, PART 2 Final Report, 31 Jul. 1985 - 31 Jul. 1987
FRANK MARCONI 30 Oct. 1987 137 p
(Contract F49620-85-C-0115)
(AD-A190245; AFOSR-87-1910TR-PT-2) Avail: NTIS HC A07/MF A01 CSCL 20D

An investigation of the power of the Euler equations in the prediction of conical separated flows is presented. These equations are solved numerically for the highly vortical supersonic flow about simple bodies. Two sources of vorticity are studied: the first is the flow field shock system and the second is the vorticity shed into the flow field from a separating boundary layer. Both sources of vorticity are found to produce separation and vortices. In the case of shed vorticity, the surface point from which the vorticity is shed (i.e., separation point) is determined empirically. At very high angles of attack the only stable separated solution is found to be asymmetric. Solutions obtained with both sources of vorticity are studied in detail, compared with each other and with potential calculations and experimental data. GRA

N88-22320# Illinois Univ., Urbana. Dept. of Mechanical and Industrial Engineering.
NUMERICAL AND EXPERIMENTAL INVESTIGATION OF MULTIPLE SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS IN A RECTANGULAR DUCT Final Technical Report, 1 Jul. 1985 - 31 Dec. 1987
J. C. DUTTON and B. F. CARROLL 6 Jan. 1988 115 p
(Contract N00014-85-K-0665)
(AD-A190772; UILU-ENG-88-4001) Avail: NTIS HC A06/MF A01 CSCL 20D

Multiple shock wave/turbulent boundary layer interactions in constant or nearly constant area supersonic duct flows occur in a variety of devices including scramjet inlets, gas ejectors, and supersonic wind tunnels. For sufficiently high duct exit pressures, a multiple shock wave/turbulent boundary layer interaction or shock train may form in the duct and cause a highly nonuniform, and possibly unsteady, flow at the duct exit. In this report, the mean flow characteristics of two shock train interactions, one with an initial Mach number of 2.5 the other at Mach 1.6, are investigated using spark Schlieren photography, surface oil flow visualization, and mean wall pressure measurements. The Mach 2.5 interaction was oblique and asymmetric in nature. A large separation occurs after the first oblique shock. The top and bottom wall boundary layer separation has been investigated, revealing that the shape of the reattachment lines and surface flow patterns for the two separation regions are quite different. This oblique shock flow pattern occurs in a neurally stable fashion with each type of opposing separation region alternately existing on either the top or bottom wall during the course of a run. A small scale unsteadiness in the shock train location, with movement on the order of a boundary layer thickness, is also observed. GRA

N88-22325*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AEROTHERMAL TESTS OF QUILTED DOME MODELS ON A FLAT PLATE AT A MACH NUMBER OF 6.5
CHRISTOPHER E. GLASS and L. ROANE HUNT May 1988 72 p
(NASA-TP-2804; L-16346; NAS 1.60:2804) Avail: NTIS HC A04/MF A01 CSCL 20D

Aerothermal tests were conducted in the NASA Langley 8 Foot High Temperature Tunnel (8'HTT) at a Mach number of 6.5 on simulated arrays of thermally bowed metallic thermal protection system (TPS) tiles at an angle of attack of 5 deg. Detailed surface pressures and heating rates were obtained for arrays aligned with the flow and skewed 45 deg diagonally to the flow with nominal bowed heights of 0.1, 0.2, and 0.4 inch submerged in both laminar and turbulent boundary layers. Aerothermal tests were made at a nominal total temperature of 3300 R, a total pressure of 400 psia, a total enthalpy of 950 Btu/lbm, a dynamic pressure of 2.7 psi, and a unit Reynolds number of 400,000 per foot. The experimental results form a data base that can be used to help protect aerothermal load increases from bowed arrays of TPS tiles. Author

N88-22326*# National Aeronautics and Space Administration, Washington, D.C.
DESIGNS OF PROFILES FOR CASCADES
L. GOETTSCHING Apr. 1988 30 p Transl. into ENGLISH from Thermodynamic and Flow Mechanical Problems in Aircraft and Spacecraft Drives (Fed. Republic of Germany, Stuttgart Univ.), Apr. 1986 p 243-267 Transl. by Scientific Translation Service, Santa Barbara, Calif. Original language document was announced as N87-14340
(Contract NASW-4307)
(NASA-TT-20161; NAS 1.77:20161; ETN-87-98751) Avail: NTIS HC A03/MF A01 CSCL 20D

Optimized cascade profiles for arbitrary applications were designed. The influence of Mach number, Reynolds number, and degree of turbulence were taken into account. The optimization aimed at maximum pressure increase, minimum pressure loss, low Reynolds number dependence, or large angle-of-attack range. Starting from the boundary layer form parameter distribution (by which transition point and separation point can be controlled) the velocity distribition and the contour were calculated. The profile characteristics were tested off-design and were improved. Interferometric measurements were performed in the transonic cascade channel. Author

N88-22330# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Theoretische Stroemungsmechanik.
THEORETICAL INVESTIGATION OF SECONDARY INSTABILITY OF THREE-DIMENSIONAL BOUNDARY-LAYER FLOWS WITH APPLICATION TO THE DFVLR-F5 MODEL WING
THOMAS M. FISCHER and UWE DALLMANN Sep. 1987 64 p
(DFVLR-FB-87-44; ISSN-0171-1342; ETN-88-92113) Avail: NTIS HC A04/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 20.50 deutsche marks

The transition of a laminar three-dimensional boundary-layer flow to a turbulent flow was studied. The transition is governed by nonlinear interactions between stationary vortex structures and instationary disturbances. In order to incorporate such interactions into a transition model, the boundary layer flow being primarily disturbed by the stationary so-called crossflow vortices was investigated locally for secondary instability. Results for the boundary layer of a swept model wing show the importance of waves traveling preferably oblique to the direction of the external inviscid flow. ESA

N88-22369# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
RELIABILITY ANALYSIS WITHIN A COMPUTER AIDED ENGINEERING (CAE) INFRASTRUCTURE

P. J. H. M. MANDERS and D. W. V.D.KWAAK 30 Sep. 1986 11 p Presented at the Reliability and Maintainability Symposium, Philadelphia, Penn., Jan. 1987
(NLR-MP-86059-U; B8733100; ETN-88-92223) Avail: NTIS HC A03/MF A01

A computer aided engineering (CAE) infrastructure for supporting the development of electronic systems, and the evaluation, and introduction, of software packages for reliability analysis of electronic systems under development is described. Prior conditions, functional requirements, performance characteristics, and implementation aspects of the CAE infrastructure as well as the reliability analysis software package are presented. The importance of a standard for common design information in the CAE infrastructure through all projects stages is discussed, and the influence of the CAE infrastructure on the requirement for reliability analysis is assessed. ESA

N88-22382*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LEWIS STRUCTURES TECHNOLOGY, 1988. VOLUME 2: STRUCTURAL MECHANICS
May 1988 307 p Symposium held in Cleveland, Ohio, 24-25 May 1988
(NASA-CP-3003-VOL-2; E-3970-VOL-2; NAS 1.55:3003-VOL-2)
Avail: NTIS HC A14/MF A01 CSCL 20K

Lewis Structures Div. performs and disseminates results of research conducted in support of aerospace engine structures. These results have a wide range of applicability to practitioners of structural engineering mechanics beyond the aerospace arena. The engineering community was familiarized with the depth and range of research performed by the division and its academic and industrial partners. Sessions covered vibration control, fracture mechanics, ceramic component reliability, parallel computing, nondestructive evaluation, constitutive models and experimental capabilities, dynamic systems, fatigue and damage, wind turbines, hot section technology (HOST), aeroelasticity, structural mechanics codes, computational methods for dynamics, structural optimization, and applications of structural dynamics, and structural mechanics computer codes.

N88-22393*# Sverdrup Technology, Inc., Cleveland, Ohio.
SPECIALTY THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS CODES
JOSEPH J. LACKNEY *In* NASA. Lewis Research Center, Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 123-129 May 1988
Avail: NTIS HC A14/MF A01 CSCL 20K

General purpose finite element computer codes that can model inelastic material behavior have been available for more than a decade. However, these codes have not been accurate enough for use in analyzing hot section engine components. To correct this problem, General Electric developed a series of nine new stand-alone computer codes for NASA. Because of the large temperature excursions associated with hot section engine components, these codes have been designed to accommodate broad variations in material behavior, including plasticity and creep. The capabilities of these computer codes are summarized. Author

N88-22418*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODE 2 FRACTURE MECHANICS
ROBERT J. BUZZARD and LOUIS GHOSN (Cleveland State Univ., Ohio.) *In its* Lewis Structures Technology, 1988. Volume 3: Structural Integrity Fatigue and Fracture Wind Turbines HOST p 149-159 May 1988
(Contract NCC3-46)
Avail: NTIS HC A16/MF A01 CSCL 20K

Current development of high-performance rolling element bearings for aircraft engines (up to 3 million DN, where DN is the product of shaft diameter in millimeters and speed in revolutions per minute) has aroused concern about fatigue crack growth in the inner bearing race that leads to catastrophic failure of the bearing and the engine. A failure sequence was postulated by Srawley, and an analytical program was undertaken to simulate fatigue crack propagation in the inner raceway of such a bearing. A fatigue specimen was developed at NASA by which fatigue data may be obtained relative to the cracking problems. The specimen may be used to obtain either mode 2 data alone or a combination of mixed-mode (1 and 2) data as well and was calibrated in this regard. Mixed-mode fracture data for M-50 bearing steel are presented, and a method for performing reversed-loading tests is described. Author

N88-22426*# Pratt and Whitney Aircraft, East Hartford, Conn.
LIFE PREDICTION MODELING BASED ON CYCLIC DAMAGE ACCUMULATION
RICHARD S. NELSON *In* NASA. Lewis Research Center, Lewis Structures Technology, 1988. Volume 3: Structural Integrity Fatigue and Fracture Wind Turbines HOST p 245-257 May 1988
(Contract NAS3-23288)
Avail: NTIS HC A16/MF A01 CSCL 14D

A high temperature, low cycle fatigue life prediction method was developed. This method, Cyclic Damage Accumulation (CDA), was developed for use in predicting the crack initiation lifetime of gas turbine engine materials, where initiation was defined as a 0.030 inch surface length crack. A principal engineering feature of the CDA method is the minimum data base required for implementation. Model constants can be evaluated through a few simple specimen tests such as monotonic loading and rapic cycle fatigue. The method was expanded to account for the effects on creep-fatigue life of complex loadings such as thermomechanical fatigue, hold periods, waveshapes, mean stresses, multiaxiality, cumulative damage, coatings, and environmental attack. A significant data base was generated on the behavior of the cast nickel-base superalloy B1900+Hf, including hundreds of specimen tests under such loading conditions. This information is being used to refine and extend the CDA life prediction model, which is now nearing completion. The model is also being verified using additional specimen tests on wrought INCO 718, and the final version of the model is expected to be adaptable to most any high-temperature alloy. The model is currently available in the form of equations and related constants. A proposed contract addition will make the model available in the near future in the form of a computer code to potential users. Author

N88-22430*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESEARCH SENSORS
DAVID R. ENGLUND *In its* Lewis Structures Technology, 1988. Volume 3: Structural Integrity Fatigue and Fracture Wind Turbines HOST p 323-335 May 1988
Avail: NTIS HC A16/MF A01 CSCL 14B

The work described is part of a program (Englund and Seasholtz, 1988) to develop sensors and sensing techniques for research applications on aircraft turbine engines. In general, the sensors are used to measure the environment at a given location within a turbine engine or to measure the response of an engine component to the imposed environment. Locations of concern are generally in the gas path and, for the most part, are within the hot section. Specific parameters of concern are dynamic gas temperature, heat flux, airfoil surface temperature, and strain on airfoils and combustor liners. To minimize the intrusiveness of surface-mounted sensors, a considerable effort was expended to develop thin-film sensors for surface temperature, strain, and heat flux measurements. In addition, an optical system for viewing the interior of an operating combustor was developed. Most of the work described is sufficiently advanced that the sensors were used and useful data were obtained. The notable exception is the work to develop a high-temperature static strain measuring capability; the work is still in progress. Author

N88-22434*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPROVEMENTS TO TILT ROTOR PERFORMANCE THROUGH PASSIVE BLADE TWIST CONTROL

MARK W. NIXON (Army Aviation Systems Command, St. Louis, Mo.) Apr. 1988 11 p
(NASA-TM-100583; NAS 1.15:100583; AVSCOM-TM-88-B-010)
Avail: NTIS HC A03/MF A01 CSCL 20K

A passive blade twist control is presented in which the twist distribution of a tilt rotor blade is elastically changed as a function of rotor speed. The elastic twist deformation is used to achieve two different blade twist distributions corresponding to the two rotor speeds used on conventional tilt rotors in hover and forward flight. By changing the blade twist distribution, the aerodynamic performance can be improved in both modes of flight. The concept presented obtains a change in twist distribution with extension-twist-coupled composite blade structure. This investigation first determines the linear twists which are optimum for each flight mode. Based on the optimum linear twist distributions, three extension-twist-coupled blade designs are developed using coupled-beam and laminate analyses integrated with an optimization analysis. The designs are optimized for maximum twist deformation subject to material strength limitations. The aerodynamic performances of the final designs are determined which show that the passive blade twist control concept is viable, and can enhance conventional tilt rotor performance. Author

N88-22446*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL DYNAMICS BRANCH RESEARCH AND ACCOMPLISHMENTS FOR FISCAL YEAR 1987
May 1988 34 p
(NASA-TM-100279; E-3920; NAS 1.15:100279) Avail: NTIS HC A03/MF A01 CSCL 20K

This publication contains a collection of fiscal year 1987 research highlights from the Structural Dynamics Branch at NASA Lewis Research Center. Highlights from the branch's four major work areas, Aeroelasticity, Vibration Control, Dynamic Systems, and Computational Structural Methods, are included in the report as well as a complete listing of the FY87 branch publications. Author

N88-23127*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VORTEX BREAKDOWN AND CONTROL EXPERIMENTS IN THE AMES-DRYDEN WATER TUNNEL
F. K. OWEN (Complere, Inc., Palo Alto, Calif.) and D. J. PEAKE *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 10 p Jun. 1987 Previously announced as N87-13409
Avail: NTIS HC A20/MF A01 CSCL 20D

Flow-field measurements have been made to determine the effects of core blowing on vortex breakdown and control. The results of these proof-of-concept experiments clearly demonstrate the usefulness of water tunnels as test platforms for advanced flow-field simulation and measurement. Author

N88-23130# Eidetics International, Inc., Torrance, Calif.
FLOW VISUALIZATION STUDY OF VORTEX MANIPULATION ON FIGHTER CONFIGURATIONS AT HIGH ANGLES OF ATTACK
GERALD N. MALCOLM and ANDREW M. SKOW *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 19 p Jun. 1987
(Contract F33615-85-C-3619)
Avail: NTIS HC A20/MF A01

Experiments were performed in a flow visualization water tunnel on a generic fighter model to explore vortex manipulation as an effective means of aircraft control by altering the natural state of the forebody and LEX vortices in the medium-to-high-angle of attack range with either small surface modifiers or blowing jets. Specifically, the forebody vortex system was examined with the clean forebody, with forebody strakes, and with forebody surface blowing. LEX vortices were examined with a clean LEX, with small geometric modifications near the apex, and with surface blowing, both in upstream and downstream directions at various locations on the LEX surface. The interactive effects of forebody and LEX/wing vortices and their response to the various methods of control were also examined. It was concluded that the forebody vortices can be effectively controlled by either blowing or using strakes, but the effectiveness is very dependent on proper radial placement of the blowing port or strake. Author

N88-23134# Technische Hochschule, Aachen (West Germany).
SHORT DURATION FLOW ESTABLISHMENT ON A PROFILE IN A WATER-LUDWIEG-TUNNEL
W. KERRES and H. GROENIG *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 12 p Jun. 1987
Avail: NTIS HC A20/MF A01

This paper deals with the time-dependent establishment of the flow field on an airfoil in unsteady flow. The impulsive part of the flow is achieved in a Water-Ludwieg-Tunnel. By using a coded particle tracing method for flow visualization, the detailed flow establishment on a NACA 0012 airfoil at 30-deg angle of attack is shown from the beginning where potential flow exists with zero circulation to a quasi-steady formation of the vortex street. Author

N88-23135# McDonnell-Douglas Research Labs., St. Louis, Mo.
EXPERIMENTAL INVESTIGATION OF HOVER FLOWFIELDS IN WATER AT THE MCDONNELL DOUGLAS RESEARCH LABORATORIES
K. R. SARIPALLI, J. C. KROUTIL, and J. R. VANHORN *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 10 p Jun. 1987
Avail: NTIS HC A20/MF A01

A new experimental facility, the Hover Research Facility (HRF), is designed to study the flowfields generated by hovering vertical takeoff and landing (VTOL) aircraft and helicopters. Water is used as the working medium because of its inherent advantages in flow visualization and laser Doppler velocimeter (LDV) measurements. The applications of the Hover Research Facility include: (1) experimental investigation of twin-jet impingement flow with application to VTOL aircraft; (2) visualization of the flowfield around a fully contoured, model supersonic fighter/attack short takeoff and vertical landing (STOVL) aircraft; and (3) performance testing of a No Tail Rotor (NOTAR) helicopter in hover mode by use of a scale model. Flow visualization and quantitative LDV data on these experiments are presented. Author

N88-23137# Leicester Univ. (England). Dept. of Engineering.
MEASUREMENTS OF AERODYNAMIC FORCES ON UNSTEADILY MOVING BLUFF PARACHUTE CANOPIES
D. J. COCKRELL, R. J. HARWOOD, and C. Q. SHEN *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 7 p Jun. 1987
Avail: NTIS HC A20/MF A01

Equations which describe the unsteady motion of bluff bodies through fluids contain certain components, termed added mass coefficients, which can only be determined by experiment. From the solutions to such equations the ways in which the shapes of parachute canopies influence the frequency of their oscillatory motion in pitch and their corresponding damping rates are required. Although a full-scale parachute canopy descends through air, oscillating in pitch as it does, experiments necessary to determine these added mass coefficients have been performed under water, using for this purpose a large ship tank from the towing carriage of which the model parachute canopies were suspended. These experiments showed that the added mass coefficients for bluff parachute canopies differed appreciably from their corresponding potential flow values. The latter were obtained from the analysis of inviscid, fluid flow around regular shapes which were representative of those parachute canopies. The significance for the prediction of the parachute's dynamic behavior in pitch is outlined. Author

N88-23138# IMI Summerfield, Kidderminster (England).
WATER FLOW VISUALISATION OF A RAMROCKET COMBUSTION CHAMBER

P. J. BOSZKO and G. S. OWEN *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 11 p Jun. 1987 Sponsored in part by Ministry of Defence
Avail: NTIS HC A20/MF A01

Flow within the combustion chamber of a ramrocket has been investigated using water flow visualization with air bubbles as tracers. Configurations with four axisymmetric intakes entering the combustion chamber at either 45 or 90 deg have been considered. A region of stable recirculatory flow has been identified at the head end of the combustion chamber and estimates have been obtained of the amount flowing through the recirculation region. Based on this information fuel jets have been designed which it is believed will aid ignition, secure flame stability, and improve combustion efficiency. The interaction between fuel jets and the recirculatory air flow has been tentatively investigated on flow visualization tests using jets of colored water. Author

N88-23139# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THE ONERA WATER TUNNELS TEST POSSIBILITIES FOR FLOW VISUALIZATION IN AERONAUTICAL AND NAVAL DOMAINS
H. WERLE *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 16 p Jun. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A20/MF A01

The ONERA water test tunnels, which for a long time were the pioneers in flow visualization, cover a broad scope of test methods and means, encompassing a wide field of applications. This paper presents an up-to-date description of the experimental techniques used for plane, axisymmetric and three-dimensional flow, and gives a survey of the most notable results achieved in domains as varied as fundamental research and aerodynamics and related hydrodynamic studies. Author

N88-23152# Saab-Scania, Linkoping (Sweden).
INVESTIGATION ON THE MOVEMENT OF VORTEX BURST POSITION WITH DYNAMICALLY CHANGING ANGLE OF ATTACK FOR A SCHEMATIC DELTAWING IN A WATERTUNNEL WITH CORRELATION TO SIMILAR STUDIES IN WINDTUNNEL
KARL W. WOLFFELT *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 8 p Jun. 1987
Avail: NTIS HC A20/MF A01

The requirements for modern military aircraft to maintain good handling qualities at very high angles of attack is one of many reasons why an increased knowledge is necessary regarding the aerodynamic behavior of vortex flows at nonstationary conditions. Linearized theory as it has been utilized in flight mechanics simulation using damping derivatives derived from forced oscillation technique, for example, may no longer be valid at such conditions. With this background some investigations have been made by SAAB-SCANIA with the aim to study the hysteresis effects for nonstationary vortex flows. A schematic delta-wing model which could also be equipped with a similar canard wing has been tested in a water tunnel. The model was supported in the tunnel by a simple mechanism by which it could be forced to move in one of four different modes, pitching or plunging with either ramp or harmonic motion. The flow over the model was visualized with air bubbles and sequences were recorded on videotape. The sequences were analyzed and the movements of the leading edge vortex burst have been studied with the main interest focused on the hysteresis effects. Author

N88-23155# Hamburg Model Basin (West Germany).
MEASUREMENTS OF THE TIME DEPENDENT VELOCITY FIELD SURROUNDING A MODEL PROPELLER IN UNIFORM WATER FLOW
JOERG BLAUROCK and GERD LAMMERS *In* AGARD, Aerodynamic and Related Hydrodynamic Studies Using Water Facilities 13 p Jun. 1987
Avail: NTIS HC A20/MF A01

As part of a research program, the flow field around an operating ship propeller was investigated in a water tunnel, using laser Doppler velocimetry. The 3-D velocity field was measured in three planes at the suction side and four planes on the pressure side of the propeller at the design thrust coefficient of K sub T = 0.185. In one of the planes in the propeller's slipstream, the measurements were repeated at thrust coefficients of K sub T = 0.12 and 0.25. The volocity profiles measured in the propeller's slipstream are compared with the induced velocities derived from design calculations, and occurring deviations are discussed. Furthermore, the instationary flow field permits study of the tip vortices at different distances behind the propeller. The measurements yield a quantitative description of the vortices, and the influence of propeller load at the blade tips on geometry and intensity of the tip vortices can be seen. Author

N88-23160*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
NONLINEAR WAVE INTERACTIONS IN SWEPT WING FLOWS
NABIL M. ELHADY May 1988 53 p
(Contract NAG1-729)
(NASA-CR-4142; NAS 1.26:4142) Avail: NTIS HC A04/MF A01 CSCL 20D

An analysis is presented which examines the modulation of different instability modes satisfying the triad resonance condition in time and space in a three-dimensional boundary layer flow. Detuning parameters are used for the wave numbers and the frequencies. The nonparallelism of the mean flow is taken into account in the analysis. At the leading-edge region of an infinite swept wing, different resonant triads are investigated that are comprised of travelling crossflow, vertical vorticity and Tollmein-Schlichting modes. The spatial evolution of the resonating triad components are studied. Author

N88-23161# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
LA RECHERCHE AEROSPATIALE, BIMONTHLY BULLETIN, NUMBER 1987-3, 238/MAY-JUNE
ESA Nov. 1987 72 p
(ESA-TT-1075; ETN-88-91977) Avail: NTIS HC A04/MF A01

Validation of turbulence models applied to transonic shock-wave/boundary-layer interaction; effect of computation parameters on the results of 3-D potential methods; infrared signature of flames: spectral data of carbon dioxide at high temperature; time stability of schemes using high order spatial discretization in the case of a convection equation; and flow around a symmetrical profile (hydrodynamic visualizations) are discussed. ESA

N88-23169# European Space Agency, Paris (France).
COMPARISON OF DIFFERENT KINDS OF COMPACT CROSSFLOW HEAT EXCHANGERS
WERNER SIEMENS (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) Mar. 1988 80 p Transl. into ENGLISH of Vergleichende Rechnungen an Kompakten Platten- und Profil-Waermetauschern (Cologne, Fed. REpublic of Germany, DFVLR), Sep. 1986 82 p Original language document was announced as N88-10305
(ESA-TT-1076; DFVLR-FB-86-63; ETN-88-92558) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 29.50 DM

A computer program for the calculation of compact heat exchangers for gas turbines was developed. The most important coefficients, pressure drops, and effectiveness of different kinds of exchangers were calculated as a function of Mach number, the dimensions of the exchanger, and the compactness. From the aerothermodynamic point of view, the plate exchanger is best, closely followed by the lancet heat exchanger. The ribs of the plate version have no significant effect on the characteristics, but are required for stiffness and uniform channel height. The tube heat exchanger can only compete as far as the transferable heat is concerned. ESA

N88-23171*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
EXPERIMENTAL STUDIES OF VORTEX FLOWS Final Report, Mar. 1984 - May 1988
L. ROBERTS and R. MEHTA Jun. 1988 8 p
(Contract NCC2-294)
(NASA-CR-182874; NAS 1.26:182874) Avail: NTIS HC A02/MF A01 CSCL 20D

This final report describes research work on vortex flows done during a four-year period beginning in March 1984 and funded by NASA Grant NCC2-294 from the Fluid Dynamics Research Branch of NASA Ames Research Center. After a brief introduction of the main topics addressed by the completed research, the accomplishments are summarized in chronological order. Author

N88-23220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTERIZED LIFE AND RELIABILITY MODELLING FOR TURBOPROP TRANSMISSIONS
M. SAVAGE, K. C. RADIL, D. G. LEWICKI (Army Aviation Research and Development Command, St. Louis, Mo.), and J. J. COY 1988 17 p Presented at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored by AIAA, ASEE, ASME and SAE
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-100918; E-4173; NAS 1.15:100918; AVSCOM-TR-87-C-37; AIAA-88-2979) Avail: NTIS HC A03/MF A01 CSCL 13I

A generalized life and reliability model is presented for parallel shaft geared prop-fan and turboprop aircraft transmissions. The transmission life and reliability model is a combination of the individual reliability models for all the bearings and gears in the main load paths. The bearing and gear reliability models are based on classical fatigue theory and the two parameter Weibull failure distribution. A computer program was developed to calculate the transmission life and reliability. The program is modular. In its present form, the program can analyze five different transmission arrangements. However, the program can be modified easily to include additional transmission arrangements. An example is included which compares the life of a compound two-stage transmission with the life of a split-torque, parallel compound two-stage transmission, as calculated by the computer program. Author

N88-23226*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LEWIS STRUCTURES TECHNOLOGY, 1988. VOLUME 1: STRUCTURAL DYNAMICS
May 1988 463 p Symposium held in Cleveland, Ohio, 24-25 May 1988
(NASA-CP-3003-VOL-1; E-3970-VOL-1; NAS 1.55:3003-VOL-1)
Avail: NTIS HC A20/MF A01 CSCL 20K

The specific purpose of the symposium was to familiarize the engineering structures community with the depth and range of research performed by the Structures Division of the Lewis Research Center and its academic and industrial partners. Sessions covered vibration control, fracture mechanics, ceramic component reliability, parallel computing, nondestructive testing, dynamical systems, fatigue and damage, wind turbines, hot section technology, structural mechanics codes, computational methods for dynamics, structural optimization, and applications of structural dynamics.

N88-23229*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
PIEZOELECTRIC PUSHERS FOR ACTIVE VIBRATION CONTROL OF ROTATING MACHINERY
ALAN B. PALAZZOLO (Texas A&M Univ., College Station.) and ALBERT F. KASCAK *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 29-46 May 1988
Avail: NTIS HC A20/MF A01 CSCL 14B

The active control of rotordynamic vibrations and stability by magnetic bearings and electromagnetic shakers have been discussed extensively in the literature. These devices, though effective, are usually large in volume and add significant weight to the stator. The use of piezoelectric pushers may provide similar degrees of effectiveness in light, compact packages. Tests are currently being conducted with piezoelectric pusher-based active vibration control. Results from tests performed on NASA test rigs as preliminary verification of the related theory are presented. Author

N88-23230*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Mechanical and Aerospace Engineering.
ACTIVE CONTROL AND SYSTEM IDENTIFICATION OF ROTORDYNAMIC STRUCTURE
M. L. ADAMS *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 47-52 May 1988
Avail: NTIS HC A20/MF A01 CSCL 20K

Four current research projects are summarized: (1) active control of rotor system dynamics; (2) attenuation of rotor vibration using controlled pressure hydrostatic bearings; (3) a new seal test facility for measuring isotropic and anisotropic linear rotordynamic characteristics; and (4) the use of rotordynamic instability thresholds to accurately measure bearing rotordynamic characteristics. Author

N88-23244*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
DEVELOPMENT OF AEROELASTIC ANALYSIS METHODS FOR TURBOROTORS AND PROPFANS, INCLUDING MISTUNING
KRISHNA RAO V. KAZA *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 247-262 May 1988
Avail: NTIS HC A20/MF A01 CSCL 20K

The NASA Lewis aeroelastic research program is focused on unstalled and stalled flutter, forced response, and whirl flutter of turborotors and propfans. The objectives are to understand the physical phenomena of cascade flutter and response including blade mistuning. Author

N88-23253*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
MODAL FORCED RESPONSE OF PROPFANS IN YAWED FLOW
G. V. NARAYANAN (Sverdrup Technology, Inc., Cleveland, Ohio.) *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 367-376 May 1988
Avail: NTIS HC A20/MF A01 CSCL 20K

A modal forced response method for propfans in yawed flow is presented. This capability exists in the Aeroelastic Stability and Response of Propfan (ASTROP3) code developed at the Lewis Research Center. The code uses three-dimensional steady and unsteady cascade aerodynamics by Williams and Hwang (1986) and a NASTRAN finite element model to represent the blade structure. In addition, many utility programs exist in ASTROP3 that help in both the preprocessing of the NASTRAN model and the postprocessing of modal response results. The postprocessing work that computes the blade vibratory displacements and stresses in yawed flow are highlighted here. Author

N88-23254*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.
VIBRATION AND FLUTTER ANALYSIS OF THE SR-7L LARGE-SCALE PROPFAN
RICHARD AUGUST (Sverdrup Technology, Inc., Cleveland, Ohio.) *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 379-392 May 1988
Avail: NTIS HC A20/MF A01 CSCL 20K

A structural and aeroelastic analysis of the SR-7L advanced turboprop is presented. Analyses were conducted for several cases at different blade pitch angles, blade support conditions, rotational speeds, free-stream Mach numbers, and number of blades. A finite element model of the final blade design was used to determine the blade's vibration behavior and its sensitivity to support stiffness. A computer code which was based on three-dimensional, subsonic, unsteady lifting surface aerodynamic theory, was used for the aeroelastic analysis to examine the blade's stability at a cruise condition of Mach 0.8 at 1700 rpm. The results showed that the calculated frequencies and mode shapes obtained agreed well with the published experimental data and that the blade is stable for that operating point. Author

N88-23255*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.

SUPERSONIC AXIAL-FLOW FAN FLUTTER

JOHN K. RAMSEY *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 393-403 May 1988

Avail: NTIS HC A20/MF A01 CSCL 20K

Lane's (1957) analytical formulation of the unsteady pressure distribution on an oscillating two-dimensional flat plate cascade in supersonic axial flow has been developed into a computer code. This unsteady aerodynamic code has shown good agreement with other published data. This code has also been incorporated into an existing aeroelastic code to analyze the NASA Lewis supersonic through-flow fan design. Author

N88-23256*# Army Aviation Systems Command, Cleveland, Ohio. Structural Dynamics Branch.

STALL FLUTTER ANALYSIS OF PROPFANS

T. S. R. REDDY (Toledo Univ., Ohio.) *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 405-419 May 1988 Previously announced as N87-18883

Avail: NTIS HC A20/MF A01 CSCL 20K

Three semi-empirical aerodynamic stall models are compared with respect to their lift and moment hysteresis loop prediction, limit cycle behavior, easy implementation, and feasibility in developing the parameters required for stall flutter prediction of advanced turbines. For the comparison of aeroelastic response prediction including stall, a typical section model and a plate structural model are considered. The response analysis includes both plunging and pitching motions of the blades. In model A, a correction of the angle of attack is applied when the angle of attack exceeds the static stall angle. In model B, a synthesis procedure is used for angles of attack above static stall angles, and the time history effects are accounted for through the Wagner function. Author

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A88-38372#

FOG PERSISTENCE ABOVE SOME AIRPORTS OF THE NORTH-ITALIAN PLAINS [LA PERSISTENZA DELLA NEBBIA SU ALCUNI AEROPORTI DELLE PIANURE DELL'ITALIA SETTENTRIONALE]

ANGELO FANTUZI (Aeronautica Militare Italiana, Servizio Meteorologico, Rome, Italy) Rivista di Meteorologia Aeronautica (ISSN 0035-6328), vol. 47, Apr.-June 1987, p. 117-124. In Italian.

By examining fog events and their persistence during the course of the day, the percent frequencies of fog persistence have been derived for durations of 0 to n hours. The graphic representation of the phenomenon has been also outlined with reference to the most critical period of the year (i.e.,from November to February). Author

A88-38679

AN INTERACTIVE METHOD FOR MODIFYING NUMERICAL MODEL WIND FORECASTS

DONALD WYLIE, CARL NORTON, and ANN WEICKMANN (Wisconsin, University, Madison) American Meteorological Society, International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology, 2nd, Miami, FL, Jan. 13-17, 1986, Paper. 4 p.

An interactive technique for NASA's Minimum Energy Routing using Interactive Techniques/Advanced Transport Operations System program has been developed. The algorithm has the ability to incorporate hand drawn graphic information into digital grids. It is noted that in the present method the number of lines, their length, and the smoothing function must all be balanced in order to produce the desired effect. The method is illustrated with several wind field corrections. R.R.

A88-39508

AIRCRAFT OBSERVATION OF THE SPECIFIC HUMIDITY AND PROCESS OF THE WATER VAPOR TRANSFER IN THE UPPER MIXED BOUNDARY LAYER

SUSUMU YAMAMOTO, MINORU GAMO, and OSAYUKI YOKOYAMA (Ministry of International Trade and Industry, National Research Institute for Pollution and Resources, Tsukuba, Japan) Meteorological Society of Japan, Journal (ISSN 0026-1165), vol. 66, Feb. 1988, p. 141-154. refs

A88-39729

AIRCRAFT NOISE AT THE GRAND CANYON NATIONAL PARK, ARIZONA, USA

ALEX J. SZECSODY IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 527-530. refs

Data from acoustical measurements performed at the Nort Rim, Point Sublime, Grand Canyon National Park, on June 29, 1985 between 1:15 and 2:00 P.M. are presented. Relationships are established between these measurements, urban sound and noise, and a historical reference for the Grand Canyon National Park. It is shown that intrusive noise from helicopters and touring aircraft has raised the ambient sound level from 43(D) to greater than 55 dB(D). Moreover, the hard reflective surfaces of the canyon walls serve to sustain these intrusive noise levels. K.K.

N88-22496# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

EXPERIMENTAL COMPARISON OF LIGHTNING SIMULATION TECHNIQUES TO CV-580 AIRBORNE LIGHTNING STRIKE MEASUREMENTS M.S. Thesis

RUDY M. BRAZA Dec. 1987 132 p

(AD-A190576; AFIT/GE/ENG/87D-5) Avail: NTIS HC A07/MF A01 CSCL 04A

Experimental tests on the Lightning Test Cylinder, which further investigated the assessment of lightning simulation techniques conducted by Butters et al., included swept frequency continuous wave (SFCW), current pulse, and shock-excitation. Designed to model the fuselage of an aircraft, the aluminum test cylinder is over ten meters long with a one meter diameter. To test the effects of various aircraft construction materials, the cylinder was constructed with an aperture where various composite and metal panels can be mounted. The research involved determination of the electrical field and magnetic field response transfer functions for each simulation test technique. With these transfer functions, analysis and comparison of the external and internal field responses between the SFCW, current pulse, and shock-excitation tests were made. A major portion of the research was to examine the validity of the linear model for the current pulse simulation technique. In this investigation, transfer functions were derived for various current pulse waveforms. The current waveforms injected into the test cylinder included a 20 kA unipolar, double-exponential pulse and two oscillatory waveforms with peak amplitudes of 20 kA and 100 kA. GRA

N88-23346# European Space Agency, Paris (France).
STANDARDIZED ICE ACCRETION THICKNESS AS A FUNCTION OF CLOUD PHYSICS PARAMETERS
HANS-EBERHARD HOFFMANN, ROLAND ROTH, and JOHANN DEMMEL (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) Mar. 1988 64 p Transl. into ENGLISH of Die Normierte Eisansatzdicke in Abhaengigkeit von Wolkenphysikalischen Parametern (Oberpfaffenhofen, Fed. Republic of Germany, DFVLR), Jan. 1987 64 p Original language document was announced as N88-10464
(ESA-TT-1080; DFVLR-FB-87-08; ETN-88-92561) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 24.50 DM

Normalized ice accretion thickness was studied using the measurement results of 38 icing research aircraft flights in icing clouds. Normalized ice accretion is the ice accretion thickness on 3 metal cylinders in flow direction, for a true air speed of 125 kt, and a flight path in clouds of 10 NM (i.e., 18.5 km). In the investigated range of liquid water content up to 0.50 g/cum, the normalized ice thickness grows linearly with increasing liquid water content; it is a little larger for cloud particules freezing instantaneously. The thickness is larger for smaller cylinder diameters. In the temperature range between minus 2 and minus 14 C, a difference in temperature has only a little influence, differences in particle phase and particle size distribution have no influence on the normalized ice accretion thickness. ESA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-38178#
NUMERICAL CALCULATIONS OF A CLASS OF OPTIMAL FLIGHT TRAJECTORIES
PEIDE WANG, TAORUI CUI, and MING HOU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A19-A25. In Chinese, with abstract in English. refs

A simplified direct multiple shooting algorithm is presented in this paper. The algorithm was developed to solve a class of optimal trajectory problems with assigned initial state variables, assigned (or partly assigned) terminal state variables, free terminal time, and bound constraint both on state and control variables. This class of problems is first transformed to a Mayer problem with fixed terminal time; then, a nonlinear programming problem is formed from the Mayer problem using direct multiple shooting technique. Satisfactory numerical results are obtained when an implementation of the presented algorithm is used to minimize the flight time of a hovercraft and to minimize the total stagnation point convective heating per unit area. Numerical calculations show that the algorithm has good convergence and no strict demands for initial guess in dealing with a flight trajectory problem. C.D.

A88-38179#
THE MODELLING TECHNIQUE OF THE FLIGHT SYSTEM IN FLIGHT SIMULATOR
ZHENYAN ZHAO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, Jan. 1988, p. A26-A33. In Chinese, with abstract in English. refs

In this paper, the general principles of erecting mathematical models of a flight simulator are presented briefly at first. Then, the mathematical models of aerodynamic coefficients, state of motion, and atmospheric environment, as well as their method of modeling, are described on the basis of the experience in developing an F-6 flight simulator and with reference to foreign relevant literatures. Author

A88-38725#
A FLEXIBLE COMPUTER PROGRAM FOR AIRCRAFT FLIGHT TEST PERFORMANCE
HAROLD K. CHENEY (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 213-218.
(AIAA PAPER 88-2125)

A flexible general computer program has been developed to determine the flight test performance results from takeoff, climb, cruise, landing, and rejected takeoff test runs. Flexibility is provided by the use of a constants file to provide configuration and detail information applicable to a specific test aircraft. Flag values are used to select the type of performance to be calculated and the various procedures available. The program provides the capability of calculating the test aerodynamic performance for fixed-wing aircraft configurations with one to four engines. Starting with a digital tape containing the measurements recorded during a test, the user is able to obtain final data in tabular, summary page, and plotted formats. The program philosophy, design features, characteristics, and benefits are presented. Author

A88-38746#
DIAGNOSTIC DESIGN REQUIREMENTS FOR INTEGRATED AVIONIC SUBSYSTEMS
GREGORY E. DAVIS (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 406-409.
(AIAA PAPER 88-2171)

This paper discusses the design requirements that should be incorporated into airborne electronics packages when making design changes. Four levels of internal diagnostics will be discussed- background self test, power up Built-In-Test, weapon system level, and peculiar device tests. These test requirements aid in enforcing a top down design approach for the subsystem to meet it's primary duty. The increased use of software controlled microprocessors in avionics designs promotes incorporating these diagnostic requirements. Subsystem checkout can be conducted over the databus without the need for special test equipment, often in less time than required test equipment can go through it's own operational check. Integration and testing of a subsystem containing comprehensive diagnostics is made easier, faster, and more thorough when a device can identify it's own problems realtime. Author

A88-38765*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT TEST RESULTS OF A VECTOR-BASED FAILURE DETECTION AND ISOLATION ALGORITHM FOR A REDUNDANT STRAPDOWN INERTIAL MEASUREMENT UNIT
F. R. MORRELL (NASA, Langley Research Center, Hampton, VA), M. L. BAILEY (PRC Kentron International, Hampton, VA), and P. R. MOTYKA (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988. 11 p. refs
(AIAA PAPER 88-2172)

Flight test results of a vector-based fault-tolerant algorithm for a redundant strapdown inertial measurement unit are presented. Because the inertial sensors provide flight-critical information for flight control and navigation, failure detection and isolation is developed in terms of a multi-level structure. Threshold compensation techniques for gyros and accelerometers, developed to enhance the sensitivity of the failure detection process to low-level failures, are presented. Four flight tests, conducted in a commercial transport type environment, were used to determine the ability of the failure detection and isolation algorithm to detect failure signals, such a hard-over, null, or bias shifts. The algorithm provided timely detection and correct isolation of flight control- and low-level failures. The flight tests of the vector-based algorithm demonstrated its capability to provide false alarm free dual fail-operational performance for the skewed array of inertial sensors. Author

A88-40707#
INTERACTIVE GEOMETRY DEFINITION AND GRID GENERATION FOR APPLIED AERODYNAMICS
H. G. PAGENDARM, E. LAURIEN, and H. SOBIECZKY (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: AIAA Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 51-57. refs
(AIAA PAPER 88-2515)
Euler and Navier-Stokes computational codes become more and more important in applied aerodynamics. For these methods, however, the flowfield and its boundaries have to be discretized very carefully and accurately. We report about a new technique, which allows the definition of surface and far-field geometries and the generation of spatial grids in a very accurate and efficient manner. Our technique uses the enormous capabilities of latest generation personal computers ('workstations') and a fast geometry and grid generator. In our new technique geometries and grids are defined or modified interactively. Thus refinements or improvements of a given discretization can be done much faster and more efficient than with conventional techniques. Our tool works with analytical accuracy. 'Key'-characteristics of the geometry like,e.g., leading and trailing edge of a wing or,e.g., upper and lower crown line of a fuselage are defined by piecewise analytical functions. Grid properties like clustering and curvature parameters of particular families of grid lines are defined likewise. Our method is extremely flexible and applies to the aerodynamics of transport aircraft, space vehicles, wind tunnels and turbomachines. Author

N88-22691# Rensselaer Polytechnic Inst., Troy, N.Y.
PROBLEMS IN NONLINEAR CONTINUUM DYNAMICS Final Progress Report
MARSHALL SLEMROD 1987 9 p
(Contract AF AFOSR-0239-85)
(AD-A190538; AFOSR-87-1769TR) Avail: NTIS HC A02/MF A01 CSCL 20K
The focus of this research was primarily feedback stabilization of distributed parameter systems. The principal investigator derived feedback operators for a general class of distributed systems, which include flexible beams, under the constraint of bounded control. Six papers were published, including Feedback Stabilization in Hilbert Space. Feedback laws are found for control systems governed by partial differential equations. In particular those control systems which give the dynamics of aeroelastic systems have been of interest. GRA

N88-23463*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A DESCRIPTION OF AN AUTOMATED DATABASE COMPARISON PROGRAM
JOHN D. MCMINN, JOHN D. SHAUGHNESSY, and P. DOUGLAS ARBUCKLE May 1988 11 p
(NASA-TM-100609; NAS 1.15:100609) Avail: NTIS HC A03/MF A01 CSCL 09B
An interactive FORTRAN computer comparison program designed to automatically locate regions of incongruity between two databases is described. The software, guided by user input parameters, incrementally compares the databases and generates plots of these regions in the databases which do not compare within a specified tolerance. Additionally, tools are provided within the software which enable the user to statistically reduce the number of data points in the databases compared. To facilitate the description of these tools, the procedures used to compare two aerodynamic databases for an F-18A fighter aircraft are detailed. Author

N88-23472*# Martin Marietta Corp., Denver, Colo.
DIGITAL AVIONICS DESIGN AND RELIABILITY ANALYZER
Feb. 1981 153 p
(Contract NAS1-15780)
(NASA-CR-181641; NAS 1.26:181641) Avail: NTIS HC A08/MF A01 CSCL 09B
The description and specifications for a digital avionics design and reliability analyzer are given. Its basic function is to provide for the simulation and emulation of the various fault-tolerant digital avionic computer designs that are developed. It has been established that hardware emulation at the gate-level will be utilized. The primary benefit of emulation to reliability analysis is the fact that it provides the capability to model a system at a very detailed level. Emulation allows the direct insertion of faults into the system, rather than waiting for actual hardware failures to occur. This allows for controlled and accelerated testing of system reaction to hardware failures. There is a trade study which leads to the decision to specify a two-machine system, including an emulation computer connected to a general-purpose computer. There is also an evaluation of potential computers to serve as the emulation computer. Author

N88-23519*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCURACY VERSUS CONVERGENCE RATES FOR A THREE DIMENSIONAL MULTISTAGE EULER CODE Final Report
ELI TURKEL (Tel-Aviv Univ., Israel) May 1988 21 p Presented at the 16th ICAS Congress, Jerusalem, Israel
(Contract NAS1-18107)
(NASA-CR-181665; ICASE-88-30; NAS 1.26:181665) Avail: NTIS HC A03/MF A01 CSCL 12A
Using a central difference scheme, it is necessary to add an artificial viscosity in order to reach a steady state. This viscosity usually consists of a linear fourth difference to eliminate odd-even oscillations and a nonlinear second difference to suppress oscillations in the neighborhood of steep gradients. There are free constants in these differences. As one increases the artificial viscosity, the high modes are dissipated more and the scheme converges more rapidly. However, this higher level of viscosity smooths the shocks and eliminates other features of the flow. Thus, there is a conflict between the requirements of accuracy and efficiency. Examples are presented for a variety of three-dimensional inviscid solutions over isolated wings. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A88-37219*
AEROACOUSTICS OF ADVANCED STOVL AIRCRAFT PLUMES
K. K. AHUJA and D. A. SPENCER (Lockheed Aeronautical Systems Co., Marietta, GA) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 531-541. refs
(Contract NAS3-23708)
(SAE PAPER 872358)
This paper summarizes a basic and well-controlled experimental study involving flow visualization and noise measurements to define the acoustic and flow fields of single plumes impinging on a simulated ground plane. The flow visualization was made by strobing a laser light source at the discrete frequencies generated by the impingement of the jets and measured by a nearfield microphone. This enabled visualization of instability waves generated by the interaction between the plumes and the sound generated during impingement, and also by dynamic coupling

between the two plumes. These data were acquired as a function of distance between the ground and the nozzle exit. Nearfield acoustic data were acquired simultaneously. Data for nozzle diameters of 0.265 in. and 0.4 in. are described. For selected nozzles, effects of exit boundary layer characteristics and nozzle protrusion through a simulated aircraft body are also presented.
Author

A88-37221* McDonnell Aircraft Co., St. Louis, Mo.
STOVL ACOUSTIC FATIGUE TECHNOLOGIES
DAVID S. GROEN (McDonnell Aircraft Co., Saint Louis, MO) IN: International Powered Lift Conference and Exposition, Santa Clara, CA, Dec. 7-10, 1987, Proceedings. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 553-562. refs
(Contract NAS3-24621)
(SAE PAPER 872360)

This paper assesses the state of the art in acoustic fatigue technologies as applied to an advanced supersonic short takeoff and vertical landing (STOVL) aircraft. The topics covered include advanced materials, fatigue, acoustic loads prediction, and stress response prediction. Advanced materials are compared from the standpoints of fatigue resistance and fatigue data availability. State of the art acoustic load prediction techniques are evaluated. Subsonic and supersonic jet noise generation mechanisms, axisymmetric and two-dimensional nozzles, and noise suppression methods are covered. Stress response prediction methods for acoustic, thermal, and maneuvering loads are addressed and the necessity of structural analysis with all three loading types applied simultaneously is assessed. Author

A88-38344
DEVELOPMENT OF FIBER OPTIC DATA BUS FOR AIRCRAFT
YUTAKA KOMOUCHI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan) and AKIRA SUEOKA (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Japan) Mitsubishi Heavy Industries Technical Review (ISSN 0026-6817), vol. 25, Feb. 1988, p. 57-60.

An account is given of the design, construction, and both ground and flight testing of a star-coupled fiber-optic data bus consisting of an optic coupler, fibers, a connector, and a transmitter/receiver. This system precludes spark/fire hazards and crosstalk problems, while offering very small size and weight for a given capability. The communication protocol for the data bus is of 1 Mbit/sec command response type, and its design attempted to minimize the effect on electronic interfaces as a result of conversion from electrical to fiber-optic buses. O.C.

A88-38380#
CALCULATION OF TRANSONIC ROTOR NOISE USING A FREQUENCY DOMAIN FORMULATION
J. PRIEUR (ONERA, Chatillon-sous-Bagneux, France) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 156-162. Research supported by the Ministere de la Defense. Previously cited in issue 22, p. 3334, Accession no. A86-45402. refs

A88-39701
NOISE-CON 87; PROCEEDINGS OF THE NATIONAL CONFERENCE ON NOISE CONTROL ENGINEERING, PENNSYLVANIA STATE UNIVERSITY, STATE COLLEGE, JUNE 8-10, 1987
JIRI TICHY, ED. and SABIH I. HAYEK, ED. (Pennsylvania State University, University Park) Conference sponsored by the Pennsylvania State University and Institute of Noise Control Engineering. Poughkeepsie, NY, Noise Control Foundation, 1987, 800 p. For individual items see A88-39702 to A88-39731.

The conference presents papers on the control of distributed structures, transfer matrix modeling of geared system vibration, gear dynamic models used in noise analysis, the influence of gear train dynamics on gear noise, an analytical parametric study of the broadband noise from axial-flow fans, and energy radiation and propagation in the nearfield of a vibrating plate. Other topics include the estimation of turbulence effects on sound propagation from low flying aircraft, the diffraction of sound by a smooth ridge, experimental evaluation of active noise control in a thin cylindrical shell, and distributed sensors and actuators for vibration control in elastic components. Consideration is also given to aircraft noise at the Grand Canyon National Park, reflection tomography imaging, and measurement techniques and results in broad-band generalized nearfield acoustical holography. K.K.

A88-39708* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMBUSTION NOISE FROM GAS TURBINE AIRCRAFT ENGINES MEASUREMENT OF FAR-FIELD LEVELS
EUGENE A. KREJSA (NASA, Lewis Research Center, Cleveland, OH) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 129-134. Previously announced in STAR as N87-17480. refs

Combustion noise can be a significant contributor to total aircraft noise. Measurement of combustion noise is made difficult by the fact that both jet noise and combustion noise exhibit broadband spectra and peak in the same frequency range. Since in-flight reduction of jet noise is greater than that of combustion noise, the latter can be a major contributor to the in-flight noise of an aircraft but will be less evident, and more difficult to measure, under static conditions. Several methods for measuring the far-field combustion noise of aircraft engines are discussed in this paper. These methods make it possible to measure combustion noise levels even in situations where other noise sources, such as jet noise, dominate. Measured far-field combustion noise levels for several turbofan engines are presented. These levels were obtained using a method referred to as three-signal coherence, requiring that fluctuating pressures be measured at two locations within the engine core in addition to the far-field noise measurement. Cross-spectra are used to separate the far-field combustion noise from far-field noise due to other sources. Spectra and directivities are presented. Comparisons with existing combustion noise predictions are made. Author

A88-39712
ESTIMATION OF TURBULENCE EFFECTS ON SOUND PROPAGATION FROM LOW FLYING AIRCRAFT
RICHARD RASPET, RICHARD K. WOLF, and MICHAEL T. BOBAK (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 215-220. refs

Conditions under which it is necessary to account for turbulence effects in sound measurements are examined. It is shown how the theory can be modified to incorporate some of the effects of varying scale. It is found that turbulence produces its largest effects when there is strong cancellation under quiet conditions. This produces large effects at low frequencies only when the source is close to the ground and at larger distances. At high frequencies, turbulence produces large effects, even at short ranges. K.K.

A88-39722* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MECHANISMS OF ACTIVE CONTROL FOR NOISE INSIDE A VIBRATING CYLINDER
HAROLD C. LESTER (NASA, Langley Research Center, Hampton, VA) and CHRIS R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 371-376.

The active control of propeller-induced noise fields inside a flexible cylinder is studied with attention given to the noise reduction mechanisms inherent in the present coupled acoustic shell model. The active noise control model consists of an infinitely long aluminum cylinder with a radius of 0.4 m and a thickness of 0.001 m. Pressure maps are shown when the two external sources are driven in-phase at a frequency corresponding to Omega = 0.22.
K.K.

A88-39725* Virginia Polytechnic Inst. and State Univ., Blacksburg.
ACTIVE CONTROL OF SOUND FIELDS IN ELASTIC CYLINDERS BY VIBRATIONAL INPUTS
J. D. JONES and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 413-418.
(Contract NAG1-390)

An experiment is performed to study the mechanisms of active control of sound fields in elastic cylinders via vibrational outputs. In the present method of control, a vibrational force input was used as the secondary control input to reduce the radiated acoustic field. For the frequencies considered, the active vibration technique provided good global reduction of interior sound even though only one actuator was used. K.K.

N88-22698*# National Aeronautics and Space Administration, Washington, D.C.
METHOD AND DEVICE FOR THE DETECTION AND IDENTIFICATION OF A HELICOPTER
HANS SIEBECKER May 1988 22 p Transl. into ENGLISH of German Patent no. DE2655520-C3 (8 Dec. 1986) 7 p Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4307)
(NASA-TT-20251; NAS 1.77:20251) Avail: NTIS HC A03/MF A01 CSCL 20C

The invention presents a method for detecting and identifying a helicopter based on its characteristic emission of energy in the visual and infrared regions as well as acoustic energy by employing a fire control computer with data storage and a device for targeting and observation. Author

N88-22702# Air Force Occupational and Environmental Health Lab., Brooks AFB, Tex.
NOISE ASSESSMENT OF UNSUPPRESSED TF-34-GE-100A ENGINE AT WARFIELD ANG, BALTIMORE, MARYLAND Final Report
WINSTON J. SHAFFER, II and JOHN C. ELLIS, II Dec. 1987 50 p
(AD-A189966; USAFOEHL-87-164EH0441LNA) Avail: NTIS HC A03/MF A01 CSCL 20A

This report presents the results of noise data measurements of an unsuppressed TF34-GE-100A engine and a community noise survey of the local area around the engine. Three recommendations were made. A two barrier design should be installed as an interim noise control measure. Justification and installation of a noise suppressor, as a long term solution, should be pursued. Day-night sound levels should continue to be monitored until adequate characterization of the airport noise environment is obtained. GRA

N88-22706# Massachusetts Inst. of Tech., Cambridge. Dept. of Ocean Engineering.
DESCRIBING THE SOURCE CREATED BY TURBULENT FLOW OVER ORIFICES AND LOUVERS M.S. Thesis
GLENN E. CANN Jun. 1987 107 p
(Contract N00228-85-G-3262)
(AD-A190254) Avail: NTIS HC A06/MF A01 CSCL 20A

Orifice and louver sound power spectra are investigated, using an intensity probe, at various wind speeds in a low noise, semi-anechoic, subsonic wind tunnel for free stream velocities below 50 meters per second. The radiated noise is created by turbulent flow over various orifice and louver geometries which are flushed mounted into the wall of a long duct. Five orifice samples of rectangular shape and various transverse dimensions as well as four louver samples with multiple rectangular and circular orifices are tested. Also investigated is the effect of the leading and trailing edge angle on the radiated sound power. The scaling laws of the excitation frequencies and the speed/power laws are presented for ratios of the boundary layer thickness to the transverse orifice dimension from 1.01 to 4.29. A detailed theoretical model is developed for rectangular shaped aperture orifices and louvers based on the work by Ffowcs Williams, Nelson, and Corcos. GRA

N88-22710*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCING-SIDE DIRECTIVITY AND RETREATING-SIDE INTERACTIONS OF MODEL ROTOR BLADE-VORTEX INTERACTION NOISE
R. M. MARTIN, W. R. SPLETTSTOESSER, J. W. ELLIOTT, and K.-J. SCHULTZ (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany) May 1988 43 p
(NASA-TP-2784; L-16354; NAS 1.60:2784; AVSCOM-TR-87-B-3) Avail: NTIS HC A03/MF A01 CSCL 20A

Acoustic data are presented from a 40 percent scale model of the four-bladed BO-105 helicopter main rotor, tested in a large aerodynamic wind tunnel. Rotor blade-vortex interaction (BVI) noise data in the low-speed flight range were acquired using a traversing in-flow microphone array. Acoustic results presented are used to assess the acoustic far field of BVI noise, to map the directivity and temporal characteristics of BVI impulsive noise, and to show the existence of retreating-side BVI signals. The characterics of the acoustic radiation patterns, which can often be strongly focused, are found to be very dependent on rotor operating condition. The acoustic signals exhibit multiple blade-vortex interactions per blade with broad impulsive content at lower speeds, while at higher speeds, they exhibit fewer interactions per blade, with much sharper, higher amplitude acoustic signals. Moderate-amplitude BVI acoustic signals measured under the aft retreating quadrant of the rotor are shown to originate from the retreating side of the rotor. Author

N88-22713# Institut Franco-Allemand de Recherches, St. Louis (France).
ACOUSTIC PROPAGATION IN THE LOW ATMOSPHERE. EXPERIMENTAL STUDY AND MODELING BY THE RADIUS METHOD [PROPAGATION ACOUSTIQUE DANS LA BASSE ATMOSPHERE. ETUDE EXPERIMENTALE ET MODELISATION PAR LA METHODE DES RAYONS]
J. VERMOREL and G. PARMENTIER 21 Nov. 1986 43 p In FRENCH; ENGLISH summary
(Contract DRET-85-053)
(ISL-CO-247/86; ETN-88-92018) Avail: NTIS HC A03/MF A01

Acoustic detection is studied with a focus on detection of helicopters. Sound propagation is analyzed as a function of soil and meteorological parameters. Acoustic sensors less sensitive to wind effects were also studied. Propagation calculations were developed, including three dimensional and unsteady computations. The results show the correlation of global acoustic pressure to meteorological parameters and the important perturbations produced by atmospheric turbulence. ESA

N88-23545*# Cambridge Acoustical Associates, Inc., Mass.
STRUCTUREBORNE NOISE MEASUREMENTS ON A SMALL TWIN-ENGINE AIRCRAFT
J. E. COLE, III and K. F. MARTINI Washington NASA Jun. 1988 71 p
(Contract NAS1-18020)
(NASA-CR-4137; NAS 1.26:4137; U-1541-349-PT-2) Avail: NTIS HC A04/MF A01 CSCL 20A

Structureborne noise measurements performed on a twin-engine aircraft (Beechcraft Baron) are reported. There are two overall objectives of the test program. The first is to obtain data to support the development of analytical models of the wing and fuselage, while the second is to evaluate effects of structural parameters on cabin noise. Measurements performed include structural and acoustic responses to impact excitation, structural and acoustic loss factors, and modal parameters of the wing. Path alterations include added mass to simulate fuel, variations in torque of bolts joining wing and fuselage, and increased acoustic absorption. Conclusions drawn regarding these measurements are presented. Author

N88-23547*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCED TURBOPROP AIRCRAFT FLYOVER NOISE: ANNOYANCE TO COUNTER-ROTATING-PROPELLER CONFIGURATIONS WITH AN EQUAL NUMBER OF BLADES ON EACH ROTOR, PRELIMINARY RESULTS
DAVID A. MCCURDY May 1988 35 p Presented at the 115th Acoustical Society of America Conference, Seattle, Wash., 16-20 May 1988
(NASA-TM-100612; NAS 1.15:100612) Avail: NTIS HC A03/MF A01 CSCL 20A

A laboratory experiment was conducted to quantify the annoyance of people to the flyover noise of advanced turboprop aircraft with counter-rotating propellers (CRP) having an equal number of blades on each rotor. The objectives were: to determine the effects of total content on annoyance; and compare annoyance to n x n CRP advanced turboprop aircraft with annoyance to conventional turboprop and jet aircraft. A computer synthesis system was used to generate 27 realistic, time-varying simulations of advanced turboprop takeoff noise in which the tonal content was systematically varied to represent the factorial combinations of nine fundamental frequencies and three tone-to-broadband noise ratios. These advanced turboprop simulations along with recordings of five conventional turboprop takeoffs and five conventional jet takeoffs were presented at three D-weighted sound pressure levels to 64 subjects in an anechoic chamber. Analyses of the subjects' annoyance judgments compare the three aircraft types and examined the effects of the differences in tonal content among the advanced turboprop noises. The annoyance prediction ability of various noise metrics is also examined. Author

N88-23548*# Sikorsky Aircraft, Stratford, Conn.
ACOUSTIC CHARACTERISTICS OF 1/20-SCALE MODEL HELICOPTER ROTORS
RAJARAMA K. SHENOY, FRED W. KOHLHEPP, and KENNETH P. LEIGHTON Aug. 1986 144 p
(Contract NAS2-11310)
(NASA-CR-177355; NAS 1.26:177355; SER-510248) Avail: NTIS HC A07/MF A01 CSCL 20A

A wind tunnel test to study the effects of geometric scale on acoustics and to investigate the applicability of very small scale models for the study of acoustic characteristics of helicopter rotors was conducted in the United Technologies Research Center Acoustic Research Tunnel. The results show that the Reynolds number effects significantly alter the Blade-Vortex-Interaction (BVI) Noise characteristics by enhancing the lower frequency content and suppressing the higher frequency content. In the time domain this is observed as an inverted thickness noise impulse rather than the typical positive-negative impulse of BVI noise. At higher advance ratio conditions, in the absence of BVI, the 1/20 scale model acoustic trends with Mach number follow those of larger scale models. However, the 1/20 scale model acoustic trends appear to indicate stall at higher thrust and advance ratio conditions. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

N88-22821# Aeritalia S.p.A., Turin (Italy). Gruppo Sistemi Avionica ed Equipaggiamenti.
INFORMATION SYSTEMS FOR QUALITY. EXPERIENCE AT THE NERVIANO AERITALIA PLANT. AVIONIC SYSTEMS AND EQUIPMENT GROUP [SISTEMA INFORMATIVO PER LA QUALITA': ESPERIENZE PRESSO LO STABILIMENTO DI NERVIANO DI AERITALIA]
G. CASATI and R. COLOMBINI 1987 10 p In ITALIAN Presented at Giornata di Studio Indicatori Qualita', Bologna, Italy, 20 Oct. 1987
(ETN-88-92274) Avail: NTIS HC A02/MF A01

The quality information system used at an aerospace industrial plant is described. The goals and the philosophy of the quality organization are discussed. Quality control and quality safety are distinguished. The quality indicators are classified in three categories: product quality indicators, process quality indicators, and project quality indicators. The structure of the quality reports is discussed, including the description of the different rates and indexes used in the report. ESA

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GENERAL

A88-38755#
DESIGN, CONSTRUCTION AND FLIGHT TESTING THE SPIRIT OF ST. LOUIS
WILLIAM IMMENSCHUH (San Diego Aerospace Museum, CA) and WILLIAM F. CHANA IN: AIAA Flight Test Conference, 4th, San Diego, CA, May 18-20, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 474-485. refs
(AIAA PAPER 88-2187)

A development and flight testing history is presented for Charles Lindbergh's Spirit of St. Louis. It is noted that the aircraft's 4.3-hour total flight time in San Diego involved no more than 2.6 hours strictly dedicated to obtaining flight test data. On the basis of this data, nevertheless, enough confidence was felt by Lindbergh to proceed with the planned New York-Paris nonstop flight. The flight test results obtained concerned such matters as side-window visibility, recoverability from stalls, aileron-induced roll rates, the adequacy of elevator control for takeoff and landing, top speed, engine reliability, and dynamic longitudinal stability. O.C.

A88-40548
AEROSPACE PROGRESS AND RESEARCH - THE FORTIETH ANNIVERSARY OF ONERA [RECHERCHES ET PROGRES AEROSPATIAUX - LE QUARANTIEME ANNIVERSAIRE DE L'ONERA]
JEAN CARPENTIER (ONERA, Chatillon-sous-Bagneux, France) Academie des Sciences (Paris), Comptes Rendus, Serie Generale, La Vie des Sciences (ISSN 0762-0969), vol. 4, Sept.-Oct. 1987, p. 405-436. In French.

The current status of ONERA activities in the domains of research, the application of research data to aeronautical construction projects, and the technical assistance given to manufacturers is reviewed. The numerical simulation of the flow around aircraft and the validation of numerical methods using research wind tunnels is discussed, in addition to the use of industrial wind tunnels for the dvelopment of aircraft, helicopters, and missiles. Propulsion research has centered around the development of turbines, ramjet engines for tactical missiles and hypersonic vehicles, and solid and liquid propellant rocket engines for missiles and launchers. Other topics considered include aircraft materials development, measurement instrumentation, and future plans. R.R.

N88-22851*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESEARCH AND TECHNOLOGY Annual Report, 1987
1987 103 p
(NASA-TM-100172; E-3740; NAS 1.15:100172) Avail: NTIS HC A06/MF A01 CSCL 05A

The NASA Lewis Research Center's research and technology accomplishments for fiscal year 1987 are summarized. It comprises approximately 100 short articles submitted by staff members of the technical directorates and is organized into four sections: aeronautics, aerospace technology (which includes space communications), space station systems, and computational support. A table of contents by subject was developed to assist the reader in finding articles of special interest. Author

N88-22853*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LANGLEY AEROSPACE TEST HIGHLIGHTS, 1987
May 1988 114 p
(NASA-TM-100595; NAS 1.15:100595) Avail: NTIS HC A06/MF A01 CSCL 05D

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Some of the significant tests which were performed during the calender year 1987 in Langley test facilites are illustrated. Both the broad range of the research and technology activities at Langley and the contributions of this work toward maintaining the U.S. leadership in aeronautic and space research are illustrated. Author

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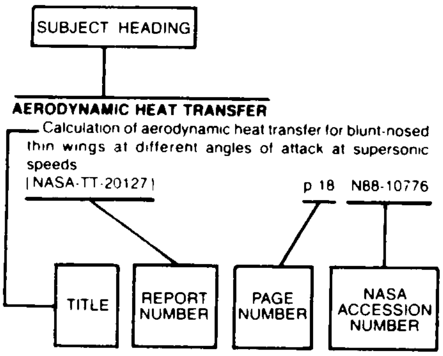

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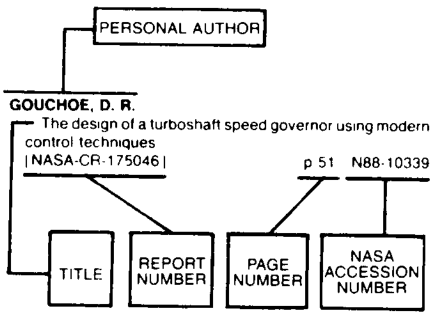

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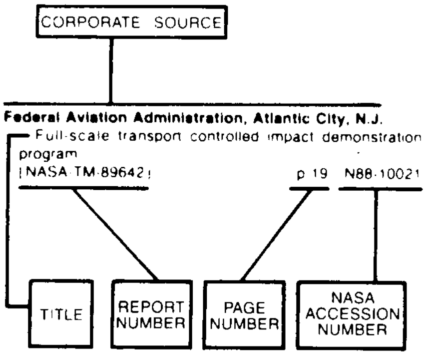

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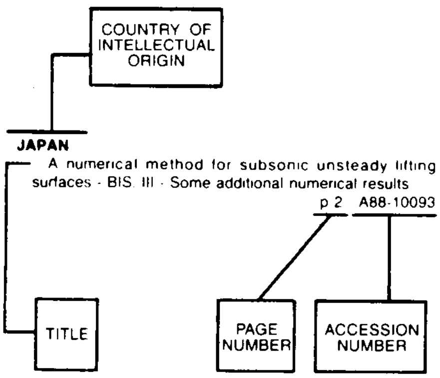

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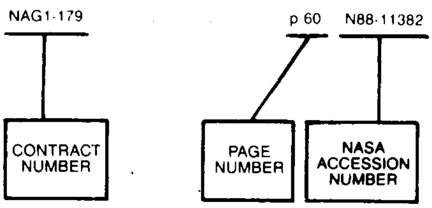

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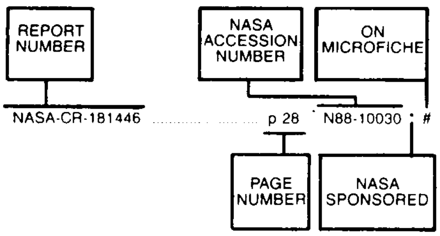

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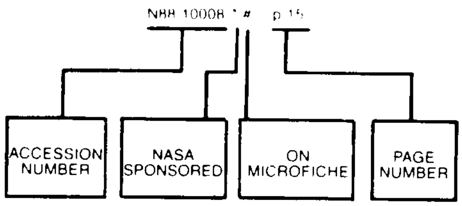

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